DRAFT

ENVIRONMENTAL IMPACT REPORT

ENVIRONMENTAL IMPACT STATEMENT

NORTH DELTA PROGRAM

November 1990

California Department of Water Resources

Gordon K. Van Vleck Secretary for Resources The Resources Agency	George Deukmejian Governor State of California	David N. Kennedy Director Department of Water Resources

Draft Environmental Impact Report
Draft Environmental Impact Statement
North Delta Program

Prepared by

California Department of Water Resources

This Environmental Impact Report/Environmental Impact Statement (EIR/EIS) is prepared in compliance with the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA).

The California Department of Water Resources (DWR) proposes to implement the North Delta Program (NDP). This program is one of three water management programs being conducted to address issues surrounding the Sacramento–San Joaquin Delta. The U.S. Army Corps of Engineers is the lead federal agency under its regulatory permits authority.

This EIR/EIS evaluates the North Delta alternative facilities, and other methods of water supply augmentation/flood control and demand–reduction. Under the NDP, eleven alternatives, including no–action, are analyzed. The preferred alternative is to: Dredge the South Fork Mokelumne River, enlarge the main stem and North Fork Mokelumne River with levee setbacks and channel dredging, enlarge the Delta Cross Channel Gate structure, acquire the necessary State and federal permits, and test mitigation river collector wells and fish screens.

The cumulative impacts of this and related projects are also evaluated.

For further information regarding this EIR/EIS, contact Stein Buer, California Department of Water Resources, 1416 Ninth Street, P. O. Box 942836, Sacramento, California 94236–0001, telephone (916) 445–6809.

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FOREWORD

This report represents the second of three related Environmental Impact Reports/Environmental Impact Statements (EIR/EIS's) being released to the public in 1990. The other two reports are: The South Delta Water Management Program (SDWMP) EIR/EIS released in June 1990, and Los Banos Grandes (LBG) Offstream Storage Reservoir EIR to be released in the near future. The North Delta Program is designed to address problems related to flooding, reverse flow, water quality, fisheries impacts, and water supply reliability. The decision-making process on this program will be coordinated with a concurrent review of the draft EIR/EIS's on the other two programs. In addition to this coordination, DWR, the Department of Fish and Game (DFG), and the U. S. Bureau of Reclamation (Reclamation) will continue to conduct public negotiations with input from environmental interests and water users to develop an agreement (s) to protect estuary fish. The planning programs are designed to be compatible with and to offer specific mitigation measures to advance this agreement(s).

This draft EIR/EIS covers actions to be taken over the next several years under the North Delta Program (NDP). The program consists of several individual actions, most of them to be undertaken by DWR as a part of the State Water Project. The U. S. Army Corps of Engineers (USACE) is the lead federal agency under its regulatory permits authority. The program features also involve the Delta waterways and facilities used by Reclamation's Central Valley Project, and, thus, potentially could influence Reclamation operations and facilities, particularly the Delta Cross Channel. Accordingly, Reclamation has joined in the preparation of this general program document as a cooperating agency and is currently involved in several of the negotiations described.

The South and North Delta Programs are responding to the growing consensus that "no action" in the Delta is unacceptable and that improvements are needed to correct existing problems. Current operation adversely affects the quality of drinking water, impacts fisheries, lowers project reliability, and creates concerns with local water diverters. Improvements proposed by these Delta water management programs are designed to reduce or eliminate these problems and assist ongoing efforts to provide flood control improvements for the Delta.

The EIR/EIS's have been organized into individual reports guided by the latest update of the California Water Plan—DWR Bulletin 160-87— to improve the decision-making processes. The use of coordinated individual reports was selected to provide added attention to program evaluations as well as flexibility in scheduling and program implementation. At the same time, the interrelationships between each program and their combined effects are addressed in detail by statewide planning documents, cumulative impact evaluations, comprehensive system operation studies, and Delta estuary mitigation activities.

David N. Kennedy, Director
Department of Water Resources
State of California

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EXECUTIVE SUMMARY

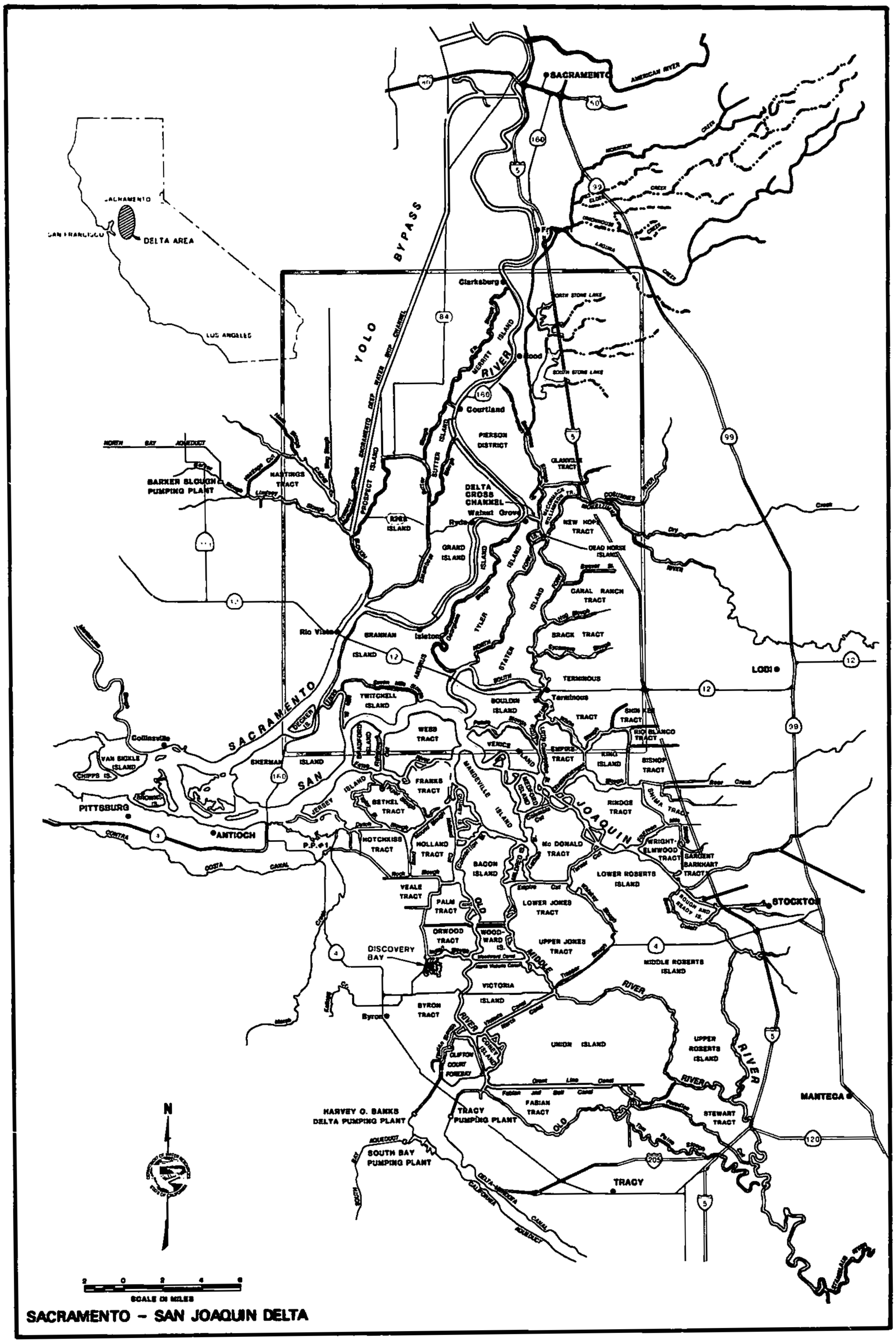


Figure 1. North Delta Program Area of Improvements

EXECUTIVE SUMMARY

The California Department of Water Resources (DWR) proposes to implement the North Delta Program (NDP). This program is one of three water management programs being conducted to address issues surrounding the Sacramento–San Joaquin Delta. The North Delta study area is shown in Figure 1. This draft report incorporates comments from earlier public scoping meetings. Additional comments from the review of this draft will be included in the final environmental document.

The environmental documentation process provides information for the public, government agencies, and decision makers about the potentially significant environmental effects of implementing the NDP. In addition, this environmental documentation will identify alternatives and possible ways to reduce or prevent environmental impacts. The information will be used to obtain regulatory permits that govern projects in the Delta estuary.

An integral part of this process is continuous communication and cooperation with the public, governmental agencies, and environmental groups to improve the decision–making process for both the preferred alternative and adopted mitigation measures. Included in this process are 1) public comments, 2) public scoping meetings, 3) wide distribution of planning reports, 4) organization of special meetings with environmental groups and interested entities, and 5) development of and commitment to implementation and monitoring of a mitigation plan.

This draft EIR/EIS covers actions to be taken over the next several years under the NDP. The program consists of several individual actions to be undertaken by DWR as a part of the State Water Project. The program features involve the same Delta waterways used by the U.S. Bureau of Reclamation (Reclamation) Central Valley Project, and, thus, potentially could influence Reclamation operations and/or facilities.

The Delta is an important resource with a complex and sensitive environment. DWR, Reclamation, and the Department of Fish and Game (DFG) have formed a negotiating group with a broad range of expertise to provide protective measures for the Bay–Delta estuary. DWR and Reclamation are committed to provide staff resources and participation to develop a mutually acceptable agreement or series of agreements. The NDP will utilize and contribute to these negotiations to develop mitigation measures. This protection, together with other commitments discussed under "Mitigation Measures," are designed to reduce adverse impacts.

The North Delta Study Area

The north Delta study area (Figure 1) includes the islands and channels south of Sacramento, north of the San Joaquin River, east of Rio Vista, and west of Thornton. The area contains about 170,000 acres of which 150,000 are used for irrigated agriculture. The remaining area consists of waterways, natural areas, levees, and lands devoted to residential, industrial, and municipal uses.

The Sacramento River, the Mokelumne River, the Cosumnes River, Dry Creek, Morrison Creek, and Deer Creek converge here in a network of meandering channels and sloughs. With the exception of Camanche Reservoir on the Mokelumne River, no designated flood bypass channels or storage facilities have been constructed for the floodflows carried by the North and South Forks of the Mokelumne River.

The Delta Cross Channel was constructed by Reclamation in 1951 to improve water conveyance through the Delta. The Delta Cross Channel, about 30 miles south of Sacramento near Walnut Grove, diverts water from the Sacramento River into eastern Delta channels, including the North and South Forks of the Mokelumne River. During periods of excessive flow in the Sacramento River, the gates of the Delta Cross Channel are closed to prevent floodwaters from the Sacramento River from increasing flooding in the interior Delta channels. During periods of normal and low flow, the gates are left open.

The most pressing problem in the north Delta study area is repeated and extensive flooding of the leveed tracts and islands. Levee failures have become common. Since 1980, there have been 14 such occurrences in the north Delta. Both the limited channel capacities and the inadequate, nonproject levees contribute to this critical problem.

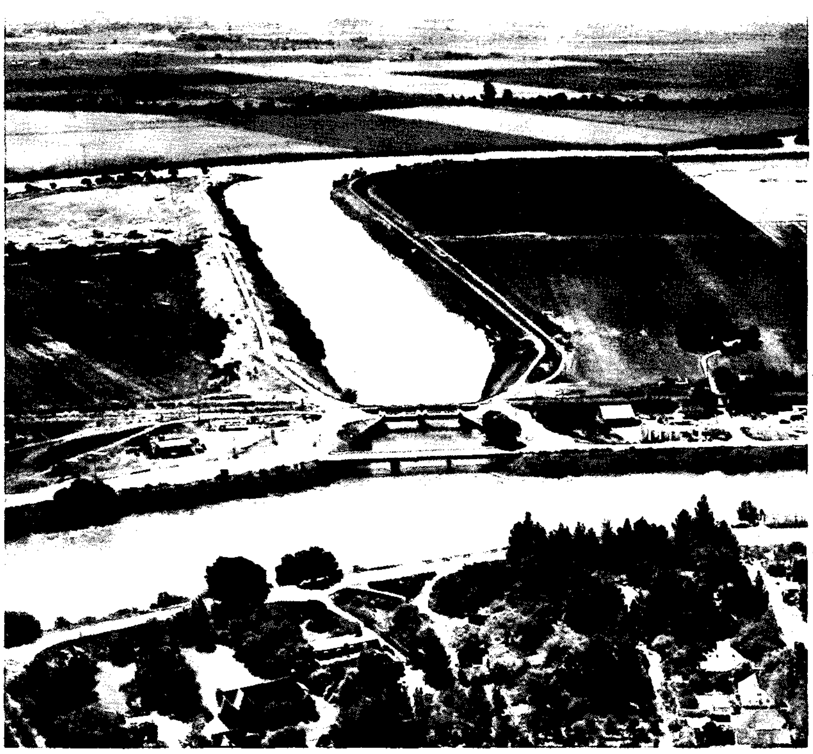
The primary source of threatening flood flows to the north Delta area are from the Cosumnes River, Dry Creek, and Mokelumne River. These streams originate in the central Sierra Nevada with a total drainage area of about 1,800 square miles.

The Morrison Creek Stream Group also contributes to flood flows and is composed of Morrison, Elder, Unionhouse, and Laguna Creeks. These streams, located in Sacramento County southeast of the city of Sacramento, flow generally westward, joining in the vicinity of the Beach–Stone Lakes area and then flowing south into Snodgrass Slough. This stream group contributes flood flows from a total drainage area of about 180 square miles.

During the February 1986 flood, massive flows from the Cosumnes River, Mokelumne River, and local creeks poured into the northeast Delta. The peak flows, which far exceeded channel capacities, flooded several islands and spilled out over low–lying areas between Freeport and Thornton.

The 1986 flooding forced evacuation of 1,600 people from small towns and various homes and businesses in the area, caused $20 million worth of direct damage, and flooded Interstate 5 and numerous local roads. Had the U.S. Army Corps of Engineers (with State and local assistance) not raised a temporary levee south of Walnut Grove, the town would have flooded, and residents would have been driven from their homes. This near disaster demonstrated the urgent need for a flood control project.

In DWR Bulletin 160–87, *California Water: Looking to the Future* (November 1987), DWR evaluated statewide water conditions. In the bulletin, DWR concluded that meeting the water needs of California's rapidly expanding population will involve a variety of water management approaches, including 1) water conservation, 2) water salvage, 3) conjunctive use of surface and ground water, 4) water transfers, 5) water sharing, 6) waste water reclamation, 7) water banking, and 8) Delta planning. The NDP

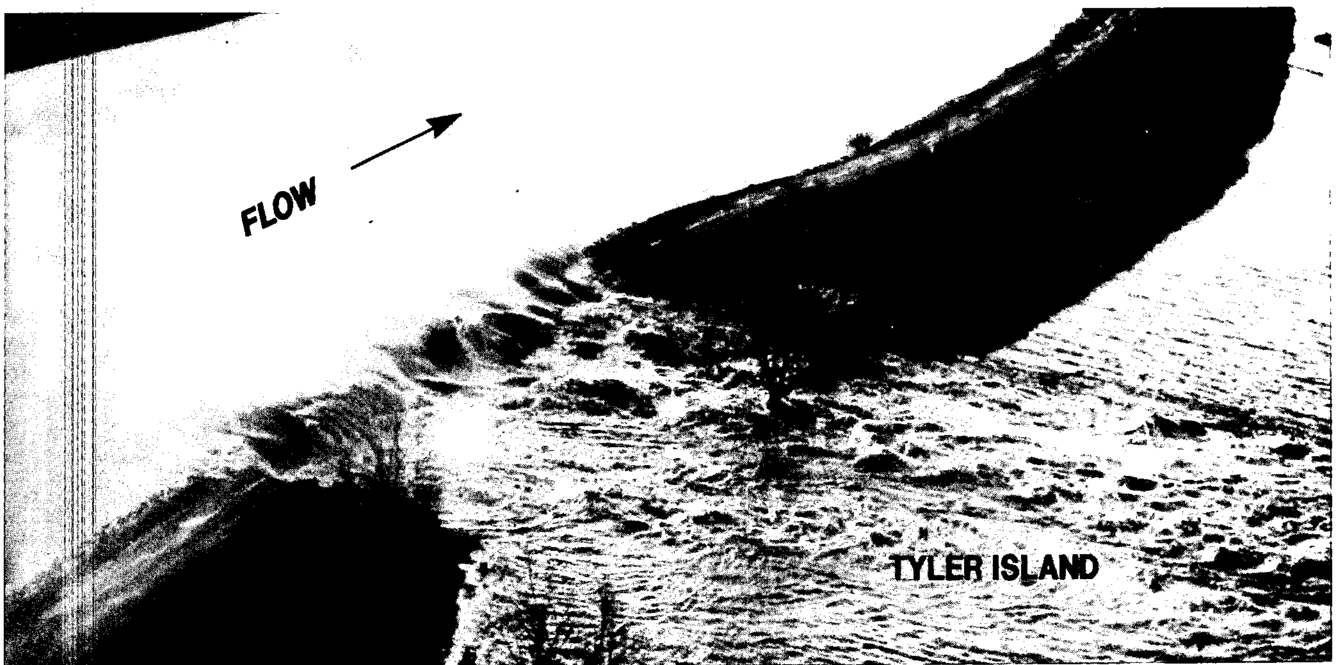


Delta Cross Channel

The Delta Cross Channel is a gated transfer channel between the Sacramento River and Snodgrass Slough. Water is diverted from the river through an earth–section channel designed to transfer approximately 3,500 cfs. The water then flows about 50 miles through natural channels to the Tracy Pumping Plant. The channel, constructed in 1950–51 as a facility of the CVP, is about 1.2 miles long.

Normal operation of the Cross Channel for flood control requires that the gates be closed when Sacramento River flows reach about 30,000 cfs, usually during winter or spring. SWRCB Decision 1485 requires various flow constraints to protect salmon and striped bass.

The proposed North Delta Water Management Program would enlarge the Delta Cross Channel gate structure from about 1,640 to about 4,500 square feet.



Water Overflowing the North Fork Mokelumne River levee during the 1986 flood

part of a statewide water plan to help meet California's future needs.

Program Need

The California Department of Water Resources (DWR) proposes to implement the NDP in two or more phases. Analysis and evaluation after completion of each phase will determine the need for and configuration of following phases.

This program is being implemented in response to:

- repeated and extensive flooding of leveed islands and tracts of the north Delta area;
- planning in south Sacramento area to include the Lambert Road flood control structure;
- statewide projections showing future increased water needs;
- drinking water concerns related to the cost and difficulty of treating Trihalomethanes (THM) precursors;
- Delta striped bass and salmonid survival problems;
- statewide declines in riparian and wetlands habitat; and
- a growing demand for recreational facilities and opportunities.

North Delta Flooding

During the February 1986 flood, massive flows from the Cosumnes River, Mokelumne River, and local creeks poured into the northeast Delta. The peak flows far exceeded channel capacities, and spilled out over low-lying areas between Freeport and Thornton. While this spreading greatly attenuated the peak flows into the northeast Delta, there was inadequate capacity in the north and south forks of the Mokelumne River to carry the remaining flows. McCormack-Williamson Tract and Glanville Tract were inundated. Levees on Deadhorse Island and Tyler Island failed after they were overtopped. The levee protecting New Hope Tract near Thornton failed due to structural weakness. Inundation of these larger islands and tracts lowered the flood waters and probably saved other islands from flooding.

The key to alleviating flooding in the north Delta is improving the conveyance capacity of the lower Mokelumne River. The north and south forks of the Mokelumne must carry all of the floodflows through the north Delta; there is no bypass system such as that used for the Sacramento River system. The limited channel capacity of the Mokelumne River and its forks restricts floodflows, causing water levels to rise. This causes overtopping and increases water pressure against levees. These problems may be worsened as upstream development increases peak inflows to the north Delta.

Program Objectives

The purpose of the NDP is to address the broad range of water management issues surrounding the Delta. The objectives of this program are to:

- Alleviate flooding in the north Delta, including the towns of Thornton and Walnut Grove;
- Reduce reverse flow in the lower San Joaquin River;
- Improve water quality;
- Reduce fishery impacts; and
- Improve State Water Project (SWP) flexibility and water supply reliability.

In addition to meeting these objectives, the program will provide the following benefits:

- Improve navigation;
- Enhance recreational opportunities; and
- Enhance wildlife habitat.

Reverse Flow

The expression "reverse flow" characterizes a Delta problem that stems from the lack of capacity in certain channels. Reverse flow occurs when there is a net movement of water upstream from the west Delta in the lower San Joaquin River and tributary sloughs toward the State and Federal export pumps near Tracy. This reverse flow disorients migratory striped bass, salmon, and steelhead. It also pulls small fish from the west Delta nursery area toward the pumping plant where they suffer heavy losses.

Reverse flow degrades the quality of water in the Delta as salty water mixes with freshwater inflows in the west Delta and is drawn toward the export pumps and Contra Costa Canal. Delta water also contains precursors of trihalomethanes (THMs), which are suspected carcinogens produced when chlorine used for disinfection reacts with organic substances during the water treatment process. Dissolved organic compounds that originate from decayed vegetation act as precursors by providing a source of carbon in trihalomethane formation reactions. During periods of reverse flow, bromides from the ocean intermix with Delta water at the western edge of Sherman Island. When bromides are present in water along with organic THM precursors, trihalomethanes are formed that contain bromine as well as chlorine, and this can increase THM levels.Drinking water supplies taken from the Delta are treated to meet current THM standards.; however, more restrictive standards are being considered by EPA.

Currently, the lack of capacity in certain channels requires additional fresh water releases from upstream reservoirs to protect drinking water, resulting in lower reservoir operational flexibility during dry conditions.

Reverse flow could be moderated by increasing the transfer efficiency of the northern Delta channels. These same improvements would benefit flood control.

Program Alternatives

The narrowing of alternatives utilized a broad range of information related to water resources planning. The selection process considered previous studies, activities implemented during droughts, legislative actions, statewide referendums, comprehensive water conservation and reclamation activities, the NDP objectives and project operational flexibility. Previous studies evaluated alternatives on the basis of such factors as economics, energy, water supply, fisheries, wildlife, recreation, water quality, technological, legal, and institutional constraints, political issues, and compatibility with other proposals.

In general, previous studies showed that an isolated facility would provide favorable reliability, fishery protection, and improved water quality when compared to other alternatives such as a physical barrier or through–Delta facility. Recent updates of previous studies showed this same trend. However, the June 1982 voter rejection by State referendum indicated that it is not politically feasible to proceed with an isolated Delta facility.

The previous studies also showed that a through–Delta system compatible with the NDP would provide significant advantages over existing conditions. Also, extensive programs since 1975 to implement water conservation and reclamation have determined that increases in statewide demands can be reduced by 1.3 MAF by 2010. This reduction is included in DWR future water supply need for year 2010.

Two types of alternatives are evaluated in this report:

- NDP alternative facilities.
- Water supply augmentation and demand–reduction alternatives, including such measures as additional water conservation and desalting.

Under the NDP, ten different alternatives and a no–action plan were evaluated. Each alternative is a combination of various project components. The components include enlarging the Delta Cross Channel gate structure, dredging river channels, constructing setback levees, and constructing island floodways. Each of the alternatives analyzed would, to varying degrees, meet the objectives of the NDP. The alternatives were formulated to guarantee evaluation of all the different project components and to evaluate the widest range of impacts. This is to ensure that, if a decision is made for a combination of facilities not specifically discussed, the impacts will be lower and the benefits greater than those under "Project Impacts."

The preferred alternative, which is a combination of facilities, has a total cost of about $290 million and includes:

1) Dredge the main stem and South Fork Mokelumne River.
2) Enlarge the main stem and North Fork Mokelumne River with levee setbacks and channel dredging.
3) Enlarge the Delta Cross Channel gate structure.
4) Acquire the necessary state and federal permits, and
5) Test mitigation river collector wells and fish screens.

Water conservation and reclamation alternatives were also evaluated. Impacts associated with conservation and reclamation programs are generally insignificant unless construction is involved. Brine disposal and energy consumption are considered as water desalting impacts.

Water conservation and reclamation measures would help reduce the projected water delivery shortfalls. These measures, however, could provide only a part of the additional water needs. In addition, these measures, alone, will neither provide operational flexibility for the SWP nor improve flood control, reduce reverse flow, improve water quality, or reduce fishery impacts of project operations. Therefore, the NDP, in conjunction with continued and increased use of water conservation and reclamation measures, is needed to meet the multi–objective goals planned for the Delta.

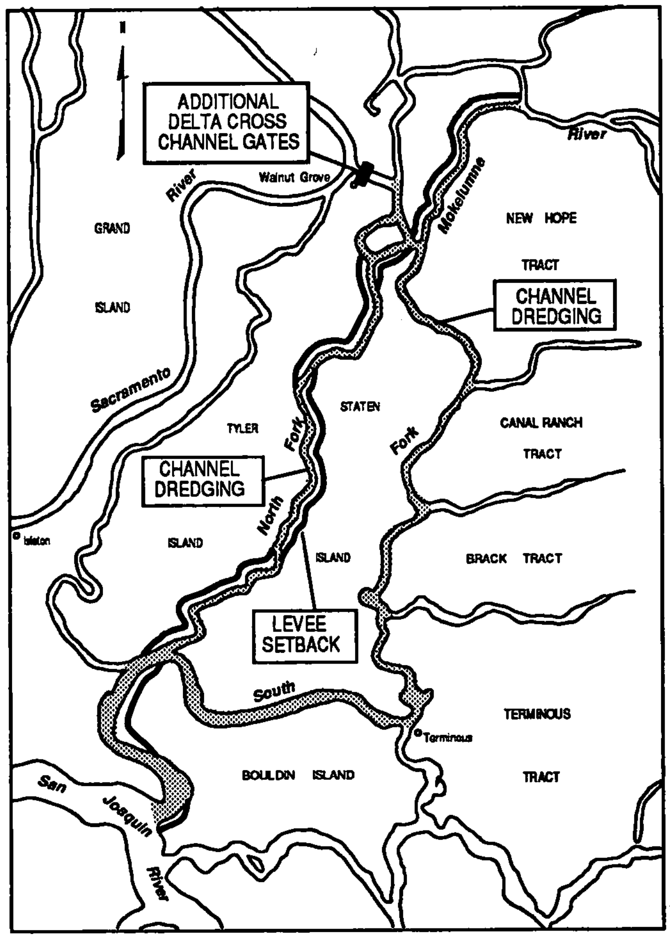


Figure 2. Preferred Alternative

Extraordinary water supply and demand reduction alternatives were compared to the alternative operational plans with the NDP. These comparisons also provided the basis for defining the municipal and industrial yield benefits of the NDP in the economic evaluation. These extraordinary measures are in addition to water conservation and waste water reclamation measures included in statewide future water supply planning. Moreover, extraordinary water conservation alternatives are needed to help offset the 400 TAF shortage expected to occur 10 percent of the time by 2010 with all currently planned expansions of the SWP, including the preferred alternative.

Program Benefits

The NDP will provide numerous benefits:

Reduce North Delta Flooding. The most pressing problem in the north Delta study area is repeated and extensive flooding of the leveed tracts and islands. Both the limited channel capacities and the inadequate levees contribute to this critical problem, as was illustrated during the February 1986 flood.

The NDP will improve the conveyance capacity of the lower Mokelumne River by dredging and levee setbacks. Channel capacity will be adequate to safely pass the 100-year flood.

Reduce Reverse Flow. Limited channel capacity in the north Delta also contributes to reverse flow in the western portion of the Delta. Reverse flow occurs when there is a net movement of water upstream from the west Delta toward the State and federal export pumps near Tracy. This reverse flow disorients migratory striped bass, salmon, and steelhead. It also pulls eggs, larvae, fish food organisms, and small fish from the west Delta nursery area toward the pumping plant, where they suffer heavy losses.

Reverse flow could be reduced by increasing the transfer efficiency of the northern Delta channels. Also, water supply for the SWP would be considerably increased. Currently, during the operational periods that cause reverse flow, more water than is otherwise needed must be released from project reservoirs to repel intruding sea water and to maintain required water quality in western Delta channels and meet export quality standards. The amount of extra outflow required is substantial.

With a reduction in reverse flow, upstream fresh water storage could be used more efficiently to repel salt water to meet Delta protective standards and export water quality needs.

Improve Water Quality. Reduction or elimination of reverse flows will improve the quality of water in the Delta. Water quality in the Delta is presently being protected by many standards, including the Safe Drinking Water Act administered by EPA, SWRCB, and by the Coordinated Operation Agreement between Reclamation and DWR. In addition, various contracts with Delta users also include other levels of water quality protection. The standards are periodically reviewed by the SWRCB to protect beneficial uses of the water supplies. However, water quality conditions can be further improved by reducing reverse flow.

Delta water also contains precursors of trihalomethanes (THMs), suspected carcinogens produced when chlorine used for disinfection reacts with natural substances during the water treatment process. Dissolved organic compounds that originate from decayed vegetation act as precursors by providing a source of carbon in trihalomethane formation reactions. During periods of reverse flow, bromides from the ocean intermix with Delta water at the western edge of Sherman Island. When bromides are present in water along with organic THM precursors, trihalomethanes are formed that contain bromine as well as chlorine.

Drinking water supplies taken from the Delta are treated to meet current THM standards; however, more restrictive standards are being considered by EPA. If adopted, tighter standards will increase the cost and difficulty of treating present Delta water sources. By reducing reverse flow, export water would follow a more direct path, avoiding ocean bromides and reducing THMs. Potential reduction in THM formation will significantly contribute toward compliance with the Safe Drinking Water Act.

Reduce Fishery Impacts. Existing measures taken to improve and protect the Delta fishery include the following:

- Delta Pumping Plant Fish Agreement;
- Protection standards for flow, quality, operation of the Delta Cross Channel and export facilities;
- Protective laws for fish and wildlife; and
- Funding for environmental research and monitoring.

Additional improvements can be provided by reduction of reverse flows, which create an undesirable environment for migrating fish, young striped bass, and fish food organisms. Reverse flows increase direct impacts on fish at the Skinner Fish Facility and other diversion points, primarily because striped bass larvae and juveniles are in high concentrations where reverse flow exists in the San Joaquin River and west Delta. During reverse flow conditions, higher concentrations of fish are carried to state, federal and local export facilities.

Fishery conditions could also be improved by constructing setback levees. New setback levees would provide more shoreline, while water-side berms can provide heavily shaded riparian habitat and shallow areas, which are important to resident fish.

Negotiations are currently under way between DWR and DFG to develop appropriate mitigation measures for current and projected project impacts in accordance with Article VII of the Two Agency Fish Agreement (1986).

Improve Project Efficiency and Water Supply Reliability. In addition to the need for improved water transport conditions in the north Delta, north Delta hydraulic improvements will be needed to meet future local and statewide water demands. The State's yearly net water needs are projected to increase some 1.4 million acre-feet (MAF) from 34.2 MAF in 1985 to 35.6 MAF in 2010. Improved north Delta hydraulics, an enlarged forebay, and a permit for SWP to pump up to 10,300 cubic feet per second (cfs) would add operational efficiency, water supply reliability, and operational flexibility to both the SWP and the CVP.

DWR estimates that the SWP could gain about 200 TAF/YR in dependable supply from the added efficiency of the NDP.

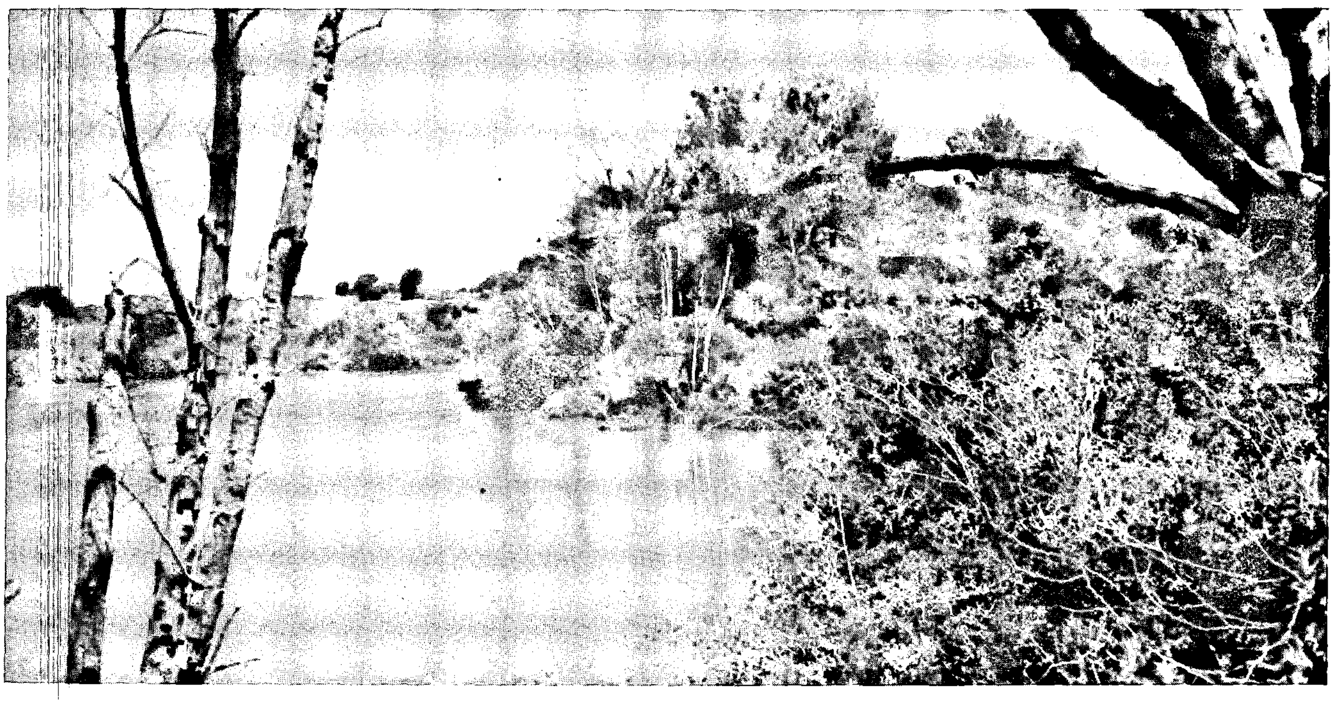
Improve Navigation. Narrow, shallow channels restrict navigation in a number of north Delta channels. Deepening and widening these channels, as well as removing some snags, will improve boating safety in the north Delta. Barge access to the levees will facilitate more cost effective levee maintenance operations.

Enhance Recreational Opportunities. Various components of the NDP would enhance recreational opportunities in the north Delta. Proposed channel improvements could lead to additional recreational development. Dredging would make accessible some scenic stretches of channel. Levee setbacks would create berm islands and additional shoreline for riparian habitat and recreation.

Details of potential recreational development can be found in the *Recreation Facilities Plan for North & South Delta* (Ebasco, March 1988). The study presents conceptual level cost estimates for several suggested recreation areas that can be developed in conjunction with the NDP. The recreational development plans are consistent with provisions of the Davis–Dolwig Act, which requires consideration of recreational facilities as part of any new SWP facility.

Enhance Wildlife Habitat. Setback levees and wide berms offer an excellent opportunity to develop habitat for wildlife. The land would be publicly owned and available for non–intensive recreation. Setback levees are the primary tool for avoidance mitigation and for providing areas for replacing or enhancing fish and wildlife values.

The necessity for levee maintenance and inspection has eliminated much of the vegetation from the levees in the Delta. Shallow marsh, riparian forest, and shaded riverine aquatic cover have been greatly reduced. The NDP can avoid impacts to these habitats and at the same time create additional habitat by setback levee construction. Desirable attributes include extensive shallow, low–veloc-



Stone Lakes Area

ity areas that have abundant vegetative cover in and over the water. The creation of uniformly deep, open water habitats or extensive high-velocity aquatic areas is not desirable. Whether such berms should be planted with trees and shrubs or allowed to revegetate naturally would be determined on a site-by-site basis.

The purchase of additional land adjacent to or near the project area for mitigation, such as the Stone Lakes Refuge, can also add to the overall enhancement of the area for fish and wildlife.

Economic Assessment

The following table shows the estimated economic benefits the NDP will provide to SWP service areas.

Region	Annual Benefit ($ million)
M&I	
South Coast	41.2
Central Coast	1.2
San Francisco Bay	3.5
Tulare Lake	1.0
Subtotal	46.9
Agricultural	
Tulare Lake	2.7
Total	**49.6**

Environmental Assessment

Table 1 summarizes the evaluation of the 11 alternatives with respect to program purposes and benefits. Environmental impacts were evaluated and compared for all the alternatives. Impacts associated with the preferred alternative are described below and summarized in Table 2.

Energy Impacts. To the extent that water deliveries through SWP facilities will increase due to implementation of the NDP, SWP energy requirements will also increase. The estimated average annual increase in energy requirements is about 1,170 gigaWatt hours (GWH). About 290 GWH of this would be recovered by SWP recovery generation on the aqueduct. Operational flexibility achieved by implementation of the NDP will also partially offset SWP energy requirements through use of both off-peak energy and short-term bulk power available in the market.

Construction Impacts. Impacts due to construction of the project components are temporary and consist of:

- increased traffic in the project area;
- disturbed vegetation in the project area;
- possible disrupted local utilities; and
- release of potentially toxic substances in channel sediments, increased turbidity and erosion associated with dredging and levee construction.

Preliminary analysis of sediments at some locations in the north Delta channels indicates that they may contain significant concentrations of mercury. Tributyltin was also detected, but there are no data currently available for determining whether the concentrations are significant. DWR is developing a dredged material testing program to quantify the concentrations and to develop management procedures for mitigating any harmful effects.

Impacts on Wildlife and Wildlife Habitat. Under the preferred alternative, agricultural land adjacent to existing channels will be purchased and converted for use in channel enlargement and mitigation lands. Losses of wildlife habitat will be fully mitigated through creation of habitat on waterside berms and existing levees left as channel islands in the enlarged channels, DWR participation in the Stone Lake Wildlife Refuge, or other mitigation measures at appropriate locations.

The reduction in flooding could impact the ecological balance in areas historically subject to inundation. The Cosumnes River Preserve and surrounding land and the Beach-Stone Lakes areas, which are prime areas for Valley Oak riparian forest and wetlands habitat restoration, may be adversely impacted by these changes.. DWR is committed to mitigating any adverse ecological impacts in these areas that may occur as a result of the proposed project and will continue to explore possible mitigation options with the responsible agencies.

Impacts on Salmon and Steelhead. Under the preferred alternative, increased water transfer through the Delta Cross Channel may cause some negative impacts to migrating salmon and steelhead. Reduced reverse flows in the lower San Joaquin River should produce benefits for migrating salmon and steelhead. Mitigation measures, including proposed temporary closures of the Delta Cross Channel gates, will be evaluated to improve existing conditions for salmon and steelhead.

Impacts on Striped Bass. Under the preferred alternative, increased water transfer through the Delta Cross Channel may cause some negative impacts to striped bass. Reductions in reverse flows in the lower San Joaquin River should produce benefits for striped bass. The net impact is expected to be neutral to positive. Mitigation measures, including proposed temporary closures of the Delta Cross Channel gates, will be evaluated to improve existing conditions for striped bass.

Impacts on Resident Fish. Direct impacts of the preferred alternative on resident game and non-game fish were evaluated. The impacts were found to be insignificant. Levee setbacks and associated berm and channel islands will create additional shallow water and shaded riverine habitat.

Potential Cumulative Effect

Table 3 shows the potential future cumulative effects of the NDP. Not all the water resources activities listed in this table will be implemented in the near future, and some will extend beyond the scope of current statewide water resources planning. Just how all these activities inter-relate is difficult to project. However, certain assumptions can be made to combine actions with mitigation and thus produce favorable effects on the cumulative impacts of the NDP. Other assumptions could combine actions without mitigation, thereby producing adverse impacts.

Mitigation Measures

Objectives of the NDP include improvement of existing conditions in the north Delta; therefore, mitigation and enhancement features are an integral part of north Delta planning:

Fish Agreement (Article VII). The existing "Agreement to Offset Direct Fish Losses in Relation to Harvey O. Banks Delta Pumping Plant" provides in Article VII for further negotiations to develop, continue, and improve mitigation measures for the Delta estuary. These negotiations, which have already begun, are between DWR, the Department of Fish and Game (DFG), and Reclamation. Negotiations are conducted publicly, and input from environmental groups and water users is encouraged.

The negotiations will include provisions for the Bay-Delta estuary along with mitigation measures that can be provided by NDP. Development of specific mitigation measures for NDP will be guided by the negotiating group. Protective measures for fish will also be designed to include measures for NDP and Los Banos Grandes, when implemented.

DWR and Reclamation are committed to the negotiation process and to the formulation of an acceptable mitigation plan for NDP.

Development of Wildlife Areas. Land acquisition and creation of channel islands and waterside berms will be included with this program. DWR is committed to participate in the Stone Lake Wildlife Refuge to provide mitigation for implementation of the NDP.

Interagency Programs. The Interagency Health Aspect Monitoring Program for the Sacramento-San Joaquin Estuary is partially funded by DWR. The Interagency Ecological Study Program involves funding by both DWR and Reclamation. Both organizations are committed to support studies conducted by the programs. These studies will provide a sound basis for mitigation measures.

Water Conservation, Water Reclamation, and Water Marketing Actions. These actions will be an integral part of all future water development. Significant reductions in demands have occurred from programs implemented since 1975. Additional programs will be implemented along with the NDP.

Mitigation for Energy Impacts. Increased SWP energy requirements will be partially offset by efficient energy consumption through use of off-peak energy.

Mitigation for Construction. Mitigation measures for construction consist of use of roads during off-peak hours, dust control, and replanting of vegetation in the project area. Such mitigation actions can reduce or eliminate the impacts caused by construction. Monitoring and management of dredged material can mitigate potentially harmful effects of toxic contaminants.

Archeological and Cultural Resources. The design and specification of the project will include avoidance of known archeological and cultural resource sites. Also, if it is determined during construction that sites meeting the criteria of the National Register would be adversely affected, the State Historic Preservation Officer will be consulted to develop acceptable mitigation procedures.

Mitigation for cumulative impacts generally consists of:

- safeguards by laws, regulations, and water rights standards;
- actions to offset losses in the estuary, such as the Suisun Marsh protection agreement to provide protection for the Marsh;
- contracts between project operators and various interests such as Delta agricultural and industrial users; and
- physical measures such as habitat improvements, grow-out facilities, fish screens, and fish hatcheries.

Environmental Commitments

- *Negotiate with DFG according to Article VII of the existing Banks Pumping Plant Fish Agreement to identify additional protective measures for the Bay-Delta estuary.*
- *Participate in development of fish protection measures according to an existing agreement, including a striped bass grow-out facility at SWP facilities and upstream measures to improve spawning.*
- *Continue existing—and, if necessary, expand—monitoring programs for sedimentation, scouring, seepage, water quality, and the effectiveness of mitigation plans.*
- *Protect wildlife and endangered species habitat losses by participating in the Stone Lake Wildlife Refuge program and protecting north Delta islands from flooding.*
- *Create high-quality channel berm habitat for rare plants by levee setback designs.*
- *Mitigate for construction impacts, including dust control and off-peak hours for transportation and replanting impacted vegetation.*
- *Mitigate for energy impacts, including best use of off-peak energy supplies, and project energy efficiency program.*
- *Perform comprehensive testing of dredged materials if used for enhancement of existing levees or construction of new levees.*
- *Advance drinking water investigations to provide for planning decisions to improve source water and treatment processes.*
- *Continue compliance with safeguards of laws, regulatory permits and water rights standards.*
- *Advance Suisun Marsh protective activities, including new facilities to implement the Protection Agreement.*
- *Provide protection for Delta M&I and agricultural water users through project operations and contract management.*
- *Continue multi-million dollar environmental investigations to help determine Bay-Delta estuary corrective measures.*
- *Obtain the necessary federal and State regulatory permits.*
- *Operate SWP under the preferred alternative to not conflict with any requirements imposed on DWR by the State and federal Endangered Species Acts.*
- *Complete the necessary archeological and cultural resources surveys for the selected alternatives. If any sites are found to be eligible for the National Register and cannot be avoided, a mitigation plan will be developed.*
- *Continue advancement of statewide water conservation and reclamation programs to lessen the demand on Delta water supplies.*
- *Participate in a recovery team for winter-run salmon and obtain appropriate agreements or permits.*
- *Operate the SWP in compliance with future Delta standards set by SWRCB as the result of current hearings.*
- *Implement the Delta Flood Protection Act to protect the environmentally rich Delta lands from inundation. Levee improvements will be made without any net loss of existing habitat.*

Table 1

ALTERNATIVE SUMMARY TABLE									
	Analysis								
ALTERNATIVE	Alleviate Flooding	Reduce Reverse Flow	Improve Water Quality	Reduce Striped Bass Impacts	Improve Water Supply Reliability	Improve Naviga-tion	Enhance Recreational Opportunities	Enhance Wildlife Habitat	Cost $ Million
1 No Action									
2A Dredge So.Fork Mokelumne River	+	+	+	0	+	+	+	0	29
2B Dredge So.Fork Mokelumne River & Enlarge Cross Channel Gates	+	++	++	0	++	+	+	0	59
3A Dredge So.Fork & No.Fork Mokelumne River	++	+	+	0	+	+	+	0	53
3B Dredge So.Fork & No.Fork Mokelumne River & Enlarge Cross Channel Gates	++	++	++	0	++	+	+	0	83
4A Enlarge So.Fork Mokelumne & Dredge No.Fork Mokelumne River	+++	+	+	0	+	++	+++	+++	368
4B Enlarge So.Fork Mokelumne River, Dredge No.Fork Mokelune River, & Enlarge Cross Channel Gates	+++	+++	+++	+	+++	++	+++	+++	398
5A Enlarge No.Fork Mokelumne River & Dredge So.Fork Mokelumne River	+++	+	+	0	+	++	+++	+++	260
5B Enlarge No.Fork Mokelumne River, Dredge So.Fork Mokelumne River, & Enlarge Cross Channel Gates	+++	+++	+++	+	+++	++	+++	+++	290
6A Create an Island Floodway	++++	+	+	0	+	0	++	--	250
6B Create an Island Floodway and Enlarge the Cross Channel Gates	++++	+++	+++	+	+++	0	++	--	280
7 Conservation, Reclamation, Desalinization, and Acceptance of Increased Risk	0	0	0	0	+++	0	0	0	780

(shaded) Preferred Alternative

Key:

+	Beneficial Impact
0	Insignificant Impact
-	Adverse Impact
U	Unknown Impact

Table 2
Summary of Environmental Assessment for the Preferred Alternative

Subjects	Environmental Assessment	Protection/Mitigation Measures
Rare, Threatened, & Endangered Species	The project will not be operated or constructed in violation of the Endangered Species Act. Improved flood control can protect Delta lands as foraging habitat for the Aleutian Canada Goose, greater sandhill crane. Swainson's Hawk habitat will be protected.	Participation in the recovery team for winter-run salmon. Study coordination for Delta smelt. Possible development of nesting habitat for Swainson's Hawk.
Resident Fish	Various species of game and non-game resident fish will have increased direct impacts, ranging from 1% to 10%.	Habitat will be improved by creating added shoreline with vegetation.
Fish Food Resources	Reduction in reverse flow will benefit *Neomysis.* More Sacramento River water with low plankton densities will flow into the Delta.	D-1485 and subsequent protection standards. Interagency ecological study program; existing and new fish protection agreements.
Suisun Marsh	Effectiveness of existing physical protective facilities and existing agreement will not be impacted by small outflow changes.	Continued development of planned physical improvements and analysis of operational procedures from ongoing monitoring program.
Construction	Environmental impacts will be short term with no significant long-term impact. Utilization of local construction work forces will preclude other housing and services impacts. There will be some increase in noise, dust, truck traffic, and turbidity; disturbance of vegetation; minor disruption of services (cables, gas lines, etc.) and some minimal recreational inconveniences.	Cal-OSHA regulations; State and federal dredging permits; use of flagmen; dust control; replanting vegetation.
Delta Outflow	Some operational changes will decrease Delta outflow during controlled flow conditions and will have minor impact on the environment. These same changes will reduce reverse flow and provide some environmental benefits. Improved upstream fresh water storage will be available to provide operational flexibility to control salinity and meet water needs.	D-1485 and subsequent protective outflow standards. Existing and new fish protection agreement. Coordinated Operation Agreement.
Delta Outflow Pulses	Minor decrease in number of pulses with unknown impact.	DWR funding contribution to the San Francisco Bay Study.
Cross-Delta Flow	Increase in Cross-Delta flows will have some impact to salmon smolts and striped bass eggs and larvae due to diversion from the Sacramento River.	Planned construction of a large forebay will provide flexibility for gate closures during periods of peak abundance. Also, possible installation of gates on Georgiana Slough will be investigated.

Table 2 (Continued) Summary of Environmental Assessment for the Preferred Alternative		
Subjects	**Environmental Assessment**	**Protection/Mitigation Measures**
Local, Municipal and Industrial Use	Possible future water quality improvements to the Contra Costa Cnal with reduced reverse flow. Reduced days of availability of offshore supply.	D-1485 and subsequent protective standards; various industrial water supply contracts; planned provisions to interconnect CCC to Clifton Court Forebay.
Drinking Water Quality	Reduced total dissolved solids, chlorides, bromides, and THM formation potential.	D-1485 and subsequent protective standards; EPA and California Department of Health Services drinking water standards; SWP contract objectives and Delta Health Aspects monitoring.
Agriculture	Use of approximately 1,040 acres of prime agricultural land to construct levees, berms, and channels. Improved flood protection for agricultural lands.	Delta Protection Act, north and south water agency contracts; temporary and drought emergency facilities; flood protection programs.
Water Supply Reliability	Improved reservoir operations can provide more than 200,000—400,000 AF of available storage to allow greater operational flexibility to meet water supply needs and control Delta salinity.	D-1485 and subsequent protective standards; federal regulatory permits; Coordinated Operation Agreement; water supply contracts.
Sedimentation, Scouring, and Seepage	Decreased velocity in the North and South Forks of the Mokelumne River could cause sedimentation; however, no scouring is expected.	Scour and seepage monitoring program will be implemented. Periodic channel dredging will be investigated.
Flooding	Significant flood protection will be provided to north Delta lands and to the towns of Walnut Grove and Thornton.	Improved channels to lower flood stages. Administration of additional coordinated flood control programs will add to protection.
Navigation	Increased channel depths will improve boating access.	Federal regulatory permits.
Recreation	Channel improvement design will incorporate boater destinstioin opportunities.	Davis-Dolwig Act.
Wildlife	Levee setbacks will provide high-quality channel island and water side berm habitat. Loss of 1,040 acres of agricultural land.	Added benefits from participation in the Stone Lakes Wildlife Refuge Program.

Table 2 (Continued) Summary of Environmental Assessment for the Preferred Alternative		
Subjects	**Environmental Assessment**	**Protection/Mitigation Measures**
Salmon and Steelhead	Increased Delta Cross–Channel flows will divert more salmonids into the interior Delta, creating a longer migrating path and higher exposure to predation.	D–1485 and subsequent protection standards provide for flow, salinity, and operational standards for Delta Cross–Channel and SWP and CVP fish protection facilities. Predation program at Clifton Court Forebay. Participation in the recovery team for winter–run salmon. Existing and new fish agreements.
General impact on Striped Bass	Beneficial changes will occur from reduced salinity and reverse flows. Some of these benefits will be reduced by increased Delta Cross–Channel flows and increased annual exports. Outflow changes will have minimal effects.	D–1485 and subsequent protection standards provide for flow, salinity, and operational standards for the Delta Cross–Channel and SWP and CVP fish protection facilities. Existing and new fish agreements.
Direct impact on Striped Bass	Annual reduction in striped bass yearly equivalent losses.	D–1485 and subsequent protection standards; predation control programs.
Wetlands	Increase in riparian/wetland area associated with channel enlargement. Implementation of NDP may reduce the severity of flooding in the Cosumnes River Preserve and Stone Lakes area.	DWR participation in wildlife habitat acquisition for Stone Lakes Refuge. DWR participation to mitigate changes in flooding regime to Cosumnes River Preserve and Stone Lakes Refuge.

Table 3 Potential Future Cumulative Effects of North Delta Water Management Facilities and Potential Related Projects or Actions on the Bay–Delta Estuary	
Project or Action	**Potential Cumulative Effect**
State Water Project Additions to Year 2010 • Delta Pumps • Interim CVP Purchase • Kern Water Bank • Los Banos Reservoir • South Delta Program • North Delta Program	Increase present dependable supply from 2.3 MAF to 3.6 MAF 90 percent of the time. Temporary 0.4 MAF shortage expected 10 percent of the time to be managed by extraordinary conservation and water management measures. Improvements in Delta flow patterns and operational flexibility can reduce fishery impacts and improve drinking water quality. Delta flood protection including protection of valuable wildlife habitat. Net decrease in Delta outflow.
Water Conservation Water Reclamation Water Transfer Water Sharing Conjunctive Use Desalination	Increase emphasis on these measures to meet future water needs. By 2010 conservation will reduce annual demands and Delta exports by 1.3 MAF. Waste water reuse will increase annually to further reduce diversions by 200,000 AF. Calaveras-Stanislaus Conjunctive Use Program could provide improved Delta inflow and water quality. Increasing population, loss of Mono Lake and Colorado River supplies and ground water contamination will further accelerate acceptance of these measures.
West Delta Water Management Program	Improvement in up to 10,000 acres of wetlands and diverse habitat for wildlife, including rare, threatened and endangered species. Protection against salinity intrusion resulting from flooding.
Suisun Marsh Agreement	Protection of 110,000 acres of estuary wetlands providing habitat for 200 species of brids and 60 species of mammals, amphibians and reptiles.
Harvey O. Banks Delta Pumping Plant Fish Agreement	Significant corrective actions for striped bass, salmon and steelhead. Specifically defines DWR mitigation commitment for increased pumping limits. Present actions include striped bass growing facility and upstream spawning restoration.
Delta Flood Protection Act	Increases protection of Delta waters from salinity intrusion due to flooding and protects valuable habitat including habitat for rare, threatened and endangered species.
Delta Wetlands Project	Project planning being conducted by private corporation. Provides added water supply and waterfowl habitat.
Storage North of the Delta	Planning is being conducted for Auburn Dam and Red Bank Project. Storage would reduce winter and spring Delta inflow and increase summer and fall inflow. Additional flood control and dry-year salinity protections would be provided.
Upper Sacramento and San Joaquin River Restoration Program	Improved fishery, wildlife, and riparian habitat to cumulatively add to estuary populations. Actions could include spawning restoration, water temperature improvements, hatchery improvements, and installation of fish screens.
Local Upstream Increased Use	Protected by area of origin law; however, will cause cumulative reduction of inflow and Delta outflow.
Drinking Water Quality. Wetland and Waste Discharge Action	Further continued reductions of Bay pollutants and restrictions of reduced wetlands loss due to development. Continued studies and actions to protect drinking water standards.

CHAPTER 1
INTRODUCTION

The California Department of Water Resources (DWR) proposes to implement the North Delta Program (NDP) in two or more phases. The primary objectives of the program are to help alleviate flooding in the north Delta area in general, and in the Towns of Thornton and Walnut Grove in particular; to reduce reverse flows in the lower San Joaquin River; to improve water quality; to reduce fishery impacts; and to improve water supply reliability. Secondary objectives are to improve navigation and to enhance recreational opportunities and wildlife habitat.

This program is being implemented in response to:

- repeated and extensive flooding of the leveed islands and tracts of the north Delta area;
- planning in south Sacramento area to include the Lambert Road flood control structure;
- statewide projections showing future increased water needs;
- drinking water concerns related to the cost and difficulty of treating trihalomethane (THM) precurors;
- Delta striped bass and salmonid survival, problems;
- dramatic statewide declines in riparian and wetlands habitat; and
- a growing demand for recreational facilities and opportunities.

The NDP affects federal, state, and local interests, and a number of permits will be required before construction of the initial phase of the project can begin. To obtain these permits, an Environmental Impact Report (EIR) is necessary under the requirements of the California Environmental Quality Act (CEQA) and an Environmental Impact Statement (EIS) is required under the National Environmental Policy Act (NEPA). In order to avoid duplication of effort, this joint EIR/EIS has been prepared to satisfy the requirements of both CEQA and NEPA. DWR is the lead state agency and the U.S. Army Corps of Engineers, Regulatory Section (USACE), is the lead federal agency.

Sacramento–San Joaquin Delta

The Sacramento–San Joaquin Delta is a unique and valuable resource. Natural runoff and floodflows from the Sacramento, San Joaquin, Mokelumne, Calaveras, and Cosumnes rivers flow into the Delta, which receives runoff from 40 percent of the State's land area. Until reclaimed by levees built in the late 1800s and early 1900s, the Delta was a tidal marsh. The Delta supports hundreds of species of fish, wildlife, and plants. It is part of an interconnected estuary system that includes the Suisun Marsh and San Francisco Bay and provides a passageway to and from the Pacific Ocean for migrating fish.

The Delta covers 700,000 acres interlaced with hundreds of miles of waterways. Much of the land is below sea level and relies on more than 1,000 miles of levees for protection against flooding. The levees protect rich agricultural land, some communities, and hundreds of miles of highways, pipelines, railroads, and power lines. Unstable levees and limited channel capacity lead to repeated and extensive flooding. The most serious recent flooding in the north Delta was in February 1986.

Water projects divert water from Delta channels to meet the needs of about two–thirds of the State's population and to irrigate about 4.5 million acres. Export facilities of the Central Valley Project and the State Water Project are in the south Delta, about 12 miles northwest of Tracy. Other diversion facilities include the North Bay Aqueduct, Contra Costa Canal, and 1,800 local irrigation diversions.

Water supplies for export by the Central Valley Project (CVP) and the State Water Project (SWP) are obtained from surplus Delta flows, when available, and from upstream reservoir releases, when Delta inflow is low and surplus flows are not available. Most of these releases and surplus flows enter the Delta via the Sacramento River and then flow by various routes to pumps in the south Delta. Some of this water is drawn to the pumps through interior Delta channels, facilitated by the Delta Cross Channel near Walnut Grove. The remaining water flows on down the Sacramento River to its confluence with the San Joaquin River in the west Delta. When freshwater outflow is low, water in the west Delta becomes brackish because it mixes with saltier ocean water entering as tidal

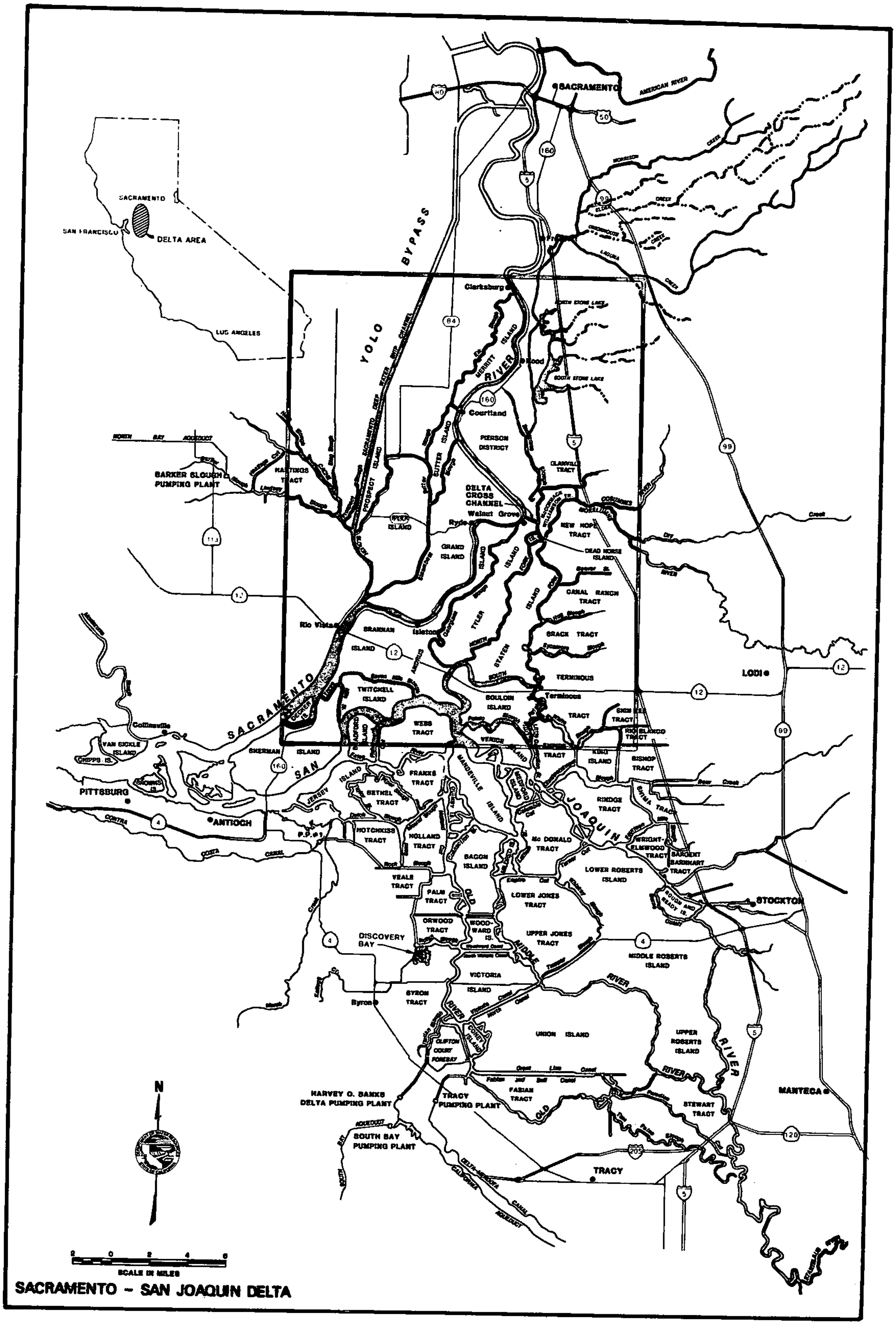


Figure 1–1. North Delta Program Area of Improvements

inflow and is drawn upstream into the San Joaquin River and other channels by the pumping plants.

Both the SWP and CVP must operate to meet many protective standards set for points throughout the Delta by the State Water Resources Control Board in Decision 1485. One demonstrable benefit of project operations is releases to control flooding and salinity intrusion. Since the construction of Shasta and Oroville reservoirs, salinity intrusion has always been stopped near Sherman Island in the western Delta. Before construction of these reservoirs, high concentrations of salts intruded approximately 20 miles further inland towards Sacramento and Stockton in dry years.

The North Delta Study Area

The north Delta study area (Figure 1-1) includes the islands and channels south of Sacramento, north of the San Joaquin River, east of Rio Vista, and west of Thornton. The area contains about 170,000 acres of which 150,000 are used for irrigated agriculture. The remaining area consists of waterways, natural areas, levees, and lands devoted to residential, industrial, and municipal uses.

The Sacramento River, the Mokelumne River, the Cosumnes River, Dry Creek, the Morrison Creek stream group converge here in a network of meandering channels and sloughs.

With the exception of Camanche Reservoir on the Mokelumne River, no designated flood bypass channels or storage facilities have been constructed for the floodflows carried by the North and South Forks of the Mokelumne River.

The Delta Cross Channel was constructed by the U. S. Bureau of Reclamation (Reclamation) in 1951 to improve water conveyance through the Delta. The Delta Cross Channel, about 30 miles south of Sacramento near Walnut Grove, diverts water from the Sacramento River into eastern Delta channels, including the north and south Forks of the Mokelumne River. During periods of excessive flow in the Sacramento River, the gates of the Delta Cross Channel are closed to prevent floodwaters from the Sacramento River from increasing flooding in the interior Delta channels. During periods of normal and low flow, the gates are left open.

Native oaks, cottonwoods, willows and tules grace the banks of many channels, sloughs, and adjoining lands, providing excellent wildlife habitat and recreational opportunities. The Delta Meadows area, along Snodgrass Slough, has especially heavy recreation use during spring and summer.

Interstate Highway 5, State Highways 12 and 160, and local roads traverse the north Delta area. In addition to providing access to towns, recreation areas and other destinations in the Delta, these roads serve as vital transportation corridors in the statewide network.

A number of small communities along the Sacramento and Mokelumne Rivers provide agricultural, recreational and other services in the area. These include Thornton, Courtland, Locke, Clarksburg, Hood, Walnut Grove, Isleton, and Terminous.

The north Delta is basically an agricultural area, but demand for more marinas and boating facilities continues to increase. There are large marinas at Terminous, Walnut Grove, Oxbow (on Georgiana Slough), New Hope, and along the south and east sides of Andrus Island. Sacramento County is receiving requests to change the agricultural zoning to allow more intensive recreational types of development, and development pressure is expected to increase.

Planning Perspective

The development and use of water in California involves a system of State and federal laws. Many of these laws are very specific to the Sacramento-San Joaquin Delta and include protective measures. This system is not fixed, but evolves year by year as new issues are raised that require changes and interpretations.

The public involvement associated with current environmental and regulatory process provides a useful forum for discussions which can lead to projects that benefit all users, including instream uses. The process encourages step-by-step negotiations. DWR has been successful in using this approach to identify concerns, interests, and alternative solutions and to move forward with projects to protect the Delta and meet future water needs of California.

The environmental documentation process provides the information necessary for federal and State regulatory permits and agreements. Federal regulatory permits are required to authorize all work in navigable waters and discharge of dredged or fill materials in waters of the United States, including wetlands. This requirement assures involvement in and review of the planning process by key federal agencies such as the Corps, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, and the Environmental Protection Agency.

CEQA/NEPA Process

The NDP will comply with and utilize the guidelines established in the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) as part of the planning process.

The California Environmental Quality Act, Public Resources Code Section 21000 et seq., establishes a strong public policy for preservation and enhancement of the State's environment. It also provides that environmental factors should be considered in planning and feasibility studies. Any facility to be constructed by or under the authority of the State requires an environmental impact report if the facility may have a significant effect on the environment.

The National Environmental Policy Act, 42 U.S.C. Section 4321 et seq., contains a strong federal commitment to preserve and enhance the human environment. It provides for preparation of an environmental impact statement for facilities constructed by the federal government or its licensees or for facilities funded by the federal government or subject to federal government approval where the project would be a major action with significant impacts on the environment.

The environmental documentation process is used to gather information on impacts, alternatives, and mitigation. Information needed for federal, State, and local permits is also being incorporated into this process. Permits are discussed in more detail in the regulatory permits section. See Chapter 7 for a discussion of environmental documentation and public involvement.

Related Delta Protective Measures

The history of water resources planning in California shows many efforts, in addition to CEQA and NEPA, to organize and implement programs that include Delta protection. A number of these protective measures are discussed below:

- Delta Protection Act
- Area of Origin Protection
- South Delta Agreements
- Delta Water Contracts
- Federal Fish Agreements for Tracy
- Banks Pumping Plant Fish Agreement
- Suisun Marsh Protection Plan
- Porter-Cologne Water Quality Control Act
- Water Rights Protective Standards
- Coordinated Operation Agreement
- Delta Flood Protection Act
- Regulatory permits
- Endangered Species Act
- Fish and Wildlife Coordination Act

Delta Protection Act. The Delta Protection Act, enacted in 1959, recognizes both the needs of the Delta and the needs for exportation of water from the Delta to other parts of the State. However, the first priority is the satisfaction of the reasonable needs for water in the Delta. The Delta needs protected by this Act include consumptive uses—such as agricultural, municipal, and industrial use.

Area of Origin Protection. The Area of Origin provisions of the Water Code set forth restrictions and limitations to protect the water requirements of the county of origin or the watershed in which water originates. Since the Burns-Porter Act declares the Delta to be part of the Sacramento River watershed, the Delta falls under area of origin protection. This protection grants the entities in areas of origin the right to construct projects or make diversions without being subject to the prior rights acquired under State applications for the SWP. It also grants the Delta, and all other areas of origin, certain preferential rights to contract for project water within the general framework established in the State water supply contracts.

South Delta Agreements. The effects of SWP and CVP operations have been studied as part of the discussions and negotiations between the South Delta Water Agency (SDWA), Reclamation, and DWR. The three agencies have been working together to develop long-term solutions to the water supply concerns of water users in the southern Delta.

To date, various agreements have been negotiated in connection with south Delta planning activities. Further negotiations are under way on a permanent agreement. The following describes the agreements, their relationship to one another, and the goals of each.

The "Agreement on Framework for Settling Litigation Brought by the South Delta Water Agency Against the

United States and the California Department of Water Resources" (October 1986) established a process for DWR, Reclamation, and SDWA to resolve the litigation filed by SDWA on July 9, 1982. The agreement includes:

- a plan to determine and to implement long-term solutions to the water supply problems in the south Delta region.
- interim actions to be implemented while the long-term solutions are being developed. Reclamation is to provide water releases from New Melones Reservoir; DWR, Reclamation, and SDWA are to develop a method of forecasting low tide conditions; and Reclamation is to consider modifying export operations when necessary.

Interim actions to be carried out by DWR are delineated in the "Joint Powers Agreement Regarding Mitigation for the South Delta" (June 1986) between DWR and SDWA. The four interim measures are: 1) dredging Tom Paine Slough (1986); 2) installing Middle River Weir (1987); 3) constructing siphons in Tom Paine Slough (1989); and 4) restricting operations at Clifton Court Forebay. (These restrictions were relaxed when the first three measures were completed).

The "Joint Powers Agreement for Tom Paine Slough" between DWR, SDWA, and Pescadero Reclamation District #2058 established details of the process for dredging Tom Paine Slough and constructing the siphons.

Delta Water Contracts. Under State law, water users in the Delta are entitled to contract with the SWP for water or water quality protection. Under a SWP contract, water entities can receive water quality benefits beyond what they would receive by virtue of the Delta standards alone. DWR has negotiated long-term agreements with the North Delta Water Agency and the East Contra Costa Irrigation District to protect agricultural uses. DWR also has contracts with western Delta municipal and industrial water users. Negotiations with Central Delta Water Agency and South Delta Water Agency (see **South Delta Agreements**) are now proceeding. SWP contracts in the Delta are discussed below:

- *North Delta Water Agency.* DWR and the North Delta Water Agency signed a contract in 1981 to protect water supply and water quality in the agency's service area, including Sherman Island. Their agreement provided for a future overland water supply facility for the island in lieu of offshore water quality. This long-proposed facility and possible alternatives are presently under study. A possible alternative, which would convert the land to wildlife habitat is discussed in the planning report, *West Delta Water Management Program*, July 1988.
- ***Western Delta Municipal Water Users.*** Two contracts are in effect for replacement of municipal water supplies in the Antioch–Pittsburg area. One is with the Contra Costa Water District (CCWD) for a municipal water diversion at Mallard Slough near Pittsburg; the second covers use by the City of Antioch. Each contract provides that DWR compensate each entity for its additional costs of purchasing a substitute water supply from the Contra Costa Canal to replace offshore supplies lost because of SWP operation.
- ***Western Delta Industrial Water Users.*** One contract is in effect with Fibreboard Corporation, a paper manufacturer at Antioch. DWR pays its share of the increased costs to purchase and treat water from the Contra Costa Canal when the water quality of Fibreboard's San Joaquin River supply deteriorates below its industrial requirements. Negotiations are continuing on a similar contract with Gaylord Container Corporation for water used by its paper mill at Antioch. Gaylord has recently purchased the Fibreboard mill.

Federal Fish Agreement For Tracy. The Bureau of Reclamation has an agreement with DWR and the Department of Fish and Game (DFG) for the biological monitoring and overseeing of the operations of the Tracy Fish Collecting Facility (along with the State's John E. Skinner Fish Protective Facility). Through the agreement, Reclamation funds a biologist to collect data and monitor the operations to improve the screening and salvaging of fish. Currently, Reclamation and DFG are negotiating on improving the CVP fish screens and on compensating for fish losses.

Banks Pumping Plant Fish Agreement. The "Agreement between the Department of Water Resources and the Department of Fish and Game to Offset Direct Fish Losses in Relation to the Harvey O. Banks Delta Pumping Plant" was signed in December 1986. Direct losses are defined as losses of fish that occur from the time fish are drawn into Clifton Court Forebay until the surviving fish are returned to the Delta. Losses occur in spite of fish screens at the pumping plant.

The agreement sets up a procedure to calculate annually direct losses of striped bass, chinook salmon, and steelhead, and requires DWR to pay for mitigation projects that would compensate for or offset the losses. Losses of other species of fish will be mitigated as impacts are identified and appropriate mitigation measures are found. DWR also provided $15 million to initiate a program that will yield "quickly demonstrated results" for the fishery resources. The monies in this fund are in addition to the compensation for annual losses as outlined in the agreement.

Fish populations in the Delta are influenced greatly by a number of complex interactions, none of which has been identified as the principal environmental factor. Delta inflow, water exports,introduction of new species, power plants, consumptive uses, upstream and local diversions, tidal action, levee failures, pollution, agricultural return flows, and recreational and commercial activities are all recognized factors that to varying degrees affect the fish resources of the Delta.

Both departments, however, recognize that the overall fishery resources dependent upon the Delta have been adversely affected by the SWP, CVP, and other water resource development projects.

Additional negotiations are being conducted under the existing agreement between DWR and DFG. Article VII of the agreement requires the parties to "...begin discussions on developing ways to offset the adverse fishery impacts in the SWP which are not covered in that agreement, including facilities needed to offset fishery impacts and provide more efficient conveyance of water." DWR and DFG wish to fulfill their obligations under Article VII of the agreement by committing to negotiations for entering into a Framework Agreement and subsequent agreements. This Framework Agreement will be designed to establish a procedural framework for commitment and execution of an agreement, or series of agreements, designed to identify, evaluate, and implement the measures necessary to improve fishery and wildlife resources in the estuary.

Reclamation has also determined that it is in its best interest to participate with DWR and DFG in the negotiations and be a signatory to the Article VII framework. After the framework agreement is finalized, the parties will evaluate the SDWMP and NDP and their potential impacts and will define special measures to mitigate and improve fishery conditions in the estuary. An agreement, or series of agreements, will be negotiated, committing the parties to implementation of mitigation measures.

In addition to DWR, Reclamation and DFG, and other representatives from the environmental, water, and fishery communities are involved in the Article VII negotiations in an advisory capacity.

Suisun Marsh Protection Plan. The objective of this program is to develop and implement a plan to mitigate the adverse effects of the SWP, the CVP, and other upstream diversions on Suisun Marsh water quality. This program directly relates to Water Rights Decision 1485 issued by the State Water Resources Control Board (SWRCB) in August 1978.

The Suisun Marsh plan of protection was developed by DWR, Reclamation, DFG, and Suisun Resources Conservation District. First-stage implementation was accomplished with construction of the initial facilities in 1980. Following completion of these facilities, the four agencies worked toward an agreement that would moderate the adverse effects of all upstream diversions on the water quality in the marsh.

The Four-Agency Suisun Marsh Preservation Agreement, as well as two auxiliary agreements, were signed in March 1987. Implementation of the plan is continuing.

The key facility of the plan, the Salinity Control Gates, was installed in 1988.

Porter-Cologne Water Quality Control Act. The Porter-Cologne Act gave State government the authority and organizational structure to regulate the quality of surface and ground water. The Act states that "...the quality of the waters of the state shall be regulated to attain the highest water quality which is reasonable...."

Enacted in 1969, the Porter-Cologne Act allows for each regional water quality control board to formulate and adopt water quality control plans for all areas within the region. Plans are adopted by the appropriate regional board to meet requirements of the Porter-Cologne Water Quality Control Act, are submitted to the SWRCB for approval, and are finally submitted to the Environmental Protection Agency for federal approval. Such plans become effective upon approval by SWRCB. Through this review and approval procedure, the plan becomes the official federal and State water quality control plan.

The federal Clean Water Bond Act was approved in 1970. This act provided funds to develop a water quality control plan, or Basin Plan, for each of the 16 planning basins in the state. The Basin Plans are prepared in accordance with the requirements of California's Porter-Cologne

Water Quality Control Act and federal water pollution control laws and regulations.

Water Rights Protective Standards. In 1967 the water quality control and water right functions of the State were merged so that necessary interrelationships between water quality and availability of unappropriated water could be considered together by a single State agency.

The water quality control plans and the water right decisions adopted by the SWRCB for the Delta represent a unified effort by SWRCB to develop under its full authority water quality objectives and standards to protect beneficial uses of Delta water supplies, recognizing the respective rights of all users to such supplies.

SWRCB has issued water right permits to DWR and Reclamation to allow those agencies to withdraw water from the Delta and export it to areas of need. In issuing the permit, the Board must reconcile, according to the California Water Code, the withdrawal of water and the prevention of unreasonable use, unreasonable method of use, or unreasonable method of diversion of water.

Realizing the intricate interaction of factors such as Delta inflow, agricultural diversions, export diversions, and the environment, SWRCB has reserved continuing jurisdiction by issuing the permits with the right of subsequent amendment of permit conditions. Consequently, beginning in 1967, hearings have been called periodically to review and adjust permit conditions to reflect updated knowledge of the Bay–Delta area. The most recent review in this series is the ongoing San Francisco Bay/Sacramento–San Joaquin Delta Estuary hearing (Bay/Delta Hearing), which convened in July 1987.

The purpose of the Bay/Delta Hearing is to review, broaden, and refine the 1978 Water Quality Control Plan and Water Rights Decision 1485 so that reasonable levels of protection for beneficial uses, as affected by flow and water quality, are provided. Beneficial uses have historically been classified under three categories: (1) fish and wildlife, (2) agricultural, and (3) municipal and industrial. SWRCB addresses the protection of beneficial uses by setting water quality objectives and standards for each of the categories at various points in the estuary. SWP facilities must operate under the constraints of the standards set in its water rights permits.

Coordinated Operation Agreement. The CVP and the SWP simultaneously use the same channels of the Sacramento River and the Delta to convey water, drawing upon a common water supply in the Delta. The purpose of a coordinated operation agreement (COA) is to assure that each project obtains its share of water from the Delta and bears its share of obligations to protect other beneficial uses of water in the Delta and the Sacramento Valley. Coordinated operation by agreed–upon criteria can increase the efficiency of both projects.

On May 20, 1985, both agencies agreed to a COA designed to increase the efficient use of existing water supplies by defining a sharing process for the SWP and the CVP to meet in–basin use and exports. The sharing formula provides for CVP/SWP proportionate splits of 75/25 responsibility for meeting in–basin use from stored water releases and 55/45 for capture and export of excess flow.

The agreement also requires both DWR and Reclamation to meet a set of protective criteria for flow standards, water quality standards, and export restrictions taken from SWRCB Water Rights Decision 1485. The projects are not to be operated to meet predetermined yields, but rather to first meet the needs in the areas of origin, including the protective criteria. Only then is water exported from the Delta. The new protective criteria at 15 additional stations add to Reclamation's water quality requirements known as Tracy standards. During normal water–supply conditions, the agreement requires about 5 MAF of Delta outflow to meet the environmental and water quality protective needs of the Delta.

In addition, the agreement addresses each party's use of the other's facilities for exchanges, conveyance, and purchases of water. Section 10 (h) of the agreement provides that DWR and Reclamation promptly negotiate a contract for 1) the SWP to wheel water for the CVP on the basis of equal priority of SWP long–term contractors, and 2) for Reclamation to sell interim CVP water to the State with a priority similar to that of long–term CVP contractors. To satisfy the protective requirements of Decision 1485, the agreement provides for conveyance (wheeling) of CVP water through the California Aqueduct to the San Luis Reservoir to make up for CVP losses from curtailment of pumping during the striped bass spawning period. The agreement also adds protection for the CVP by assuring wheeling priority during periods of CVP and SWP scheduled and unscheduled maintenance.

Delta Flood Protection Act. This Act of 1988 creates the Delta Flood Protection Fund, which establishes Legislative intent to make $12 million a year available for 10 years for flood protection in the Delta. The act makes available $6 million annually for local assistance under the

Delta Levee Maintenance Subventions Program. The remaining $6 million is for special flood control projects for eight western Delta islands and the towns of Walnut Grove and Thornton.

As required by the Act, DWR developed a plan of action for flood control for the towns of Thornton and Walnut Grove, and submitted the plan to the Legislature in January 1989. The plan was approved by the Legislature in July, 1989, and efforts are now under way to implement it.

The plan calls for prompt interim action, long-term protection, coordination, cost sharing and future studies. The highest priority interim action is to improve the stability of the 5.4 miles of levee, east and upstream from Interstate Highway 5 (I-5), which is most important in protecting Thornton from flooding by the Mokelumne River and its tributaries.

The Town of Walnut Grove is currently protected by levees that meet National Flood Insurance Program (NFIP) standards; however, additional interim actions for Walnut Grove were recommended in the plan of action. The most important is to provide an all weather gravel surface for the levee system surrounding the town.

Efforts are currently underway to implement the interim measures. Implementation involves development of agreements for local cost sharing, development of appropriate mitigation for levee work, and development of final design and construction documents.

Further actions were recommended to provide long-term protection for the entire area since expected upstream development and ongoing activities to raise levees on nearby islands will continually increase peak flood stage elevations. To reduce flood stages and provide this long term protection, DWR recommended increasing the flood carrying capacity of the South Fork of the Mokelumne River by dredging and levee setbacks. These recommendations are compatible with the NDP discussed in this report.

The Delta Flood Protection Act also requires investigation of other flood control measures, such as provisions to acquire easements up to 400 feet wide along levees to minimize tillage and to modify land management practices. DWR is directed to seek appropriate cost sharing for flood control plans. Provisions for protection of fish and wildlife habitat, as determined by the DFG, are to be included in these plans. The Delta Master Recreation Plan also needs to be considered in this planning effort.

Key Agency Responsibilities

A number of Federal, State, county and local agencies exercise authority over land use, water management, wildlife management, fisheries, and recreation in the Delta.

USACE has been actively involved in Delta navigation and flood control projects since 1877, completing four major flood control projects and eight navigation improvement projects.

USACE flood control projects include the Sacramento River Flood Control Project, Mormon Slough, the Calaveras River Flood Control Project, the Lower San Joaquin and Tributaries Flood Control Project, and the Sacramento River Bank Protection Project. In the north Delta study area, project levees constructed by USACE now line the Sacramento River, Steamboat Slough, Georgiana Slough, Threemile Slough, Sutter Slough, Elk Slough, and other waterways (Figure 1-2).

USACE has also been active in Delta planning activities since 1962. In response to Congressional resolutions in 1948 and 1961 and Section 205 of the Flood Control Act (approved May 17, 1950), USACE initiated the Sacramento-San Joaquin Delta Investigation in 1962. Intermittent work on this study, in close cooperation with DWR, eventually led to the release, in October 1982, of a draft feasibility report and draft environmental impact statement (EIS) for the Sacramento-San Joaquin Delta. This report set forth project alternatives for providing additional flood protection, controlling tidal salinity intrusion, enhancing recreational opportunities, and preserving scenic values.

In addition to its historic leadership role in Delta flood control, Section 10 of the Rivers and Harbors Act stipulates that USACE regulate structures or work affecting navigable waters of the United States. Also, Section 404 of the National Clean Water Act stipulates that USACE regulate discharges of dredged or fill material in waters of the United States, which includes wetlands.

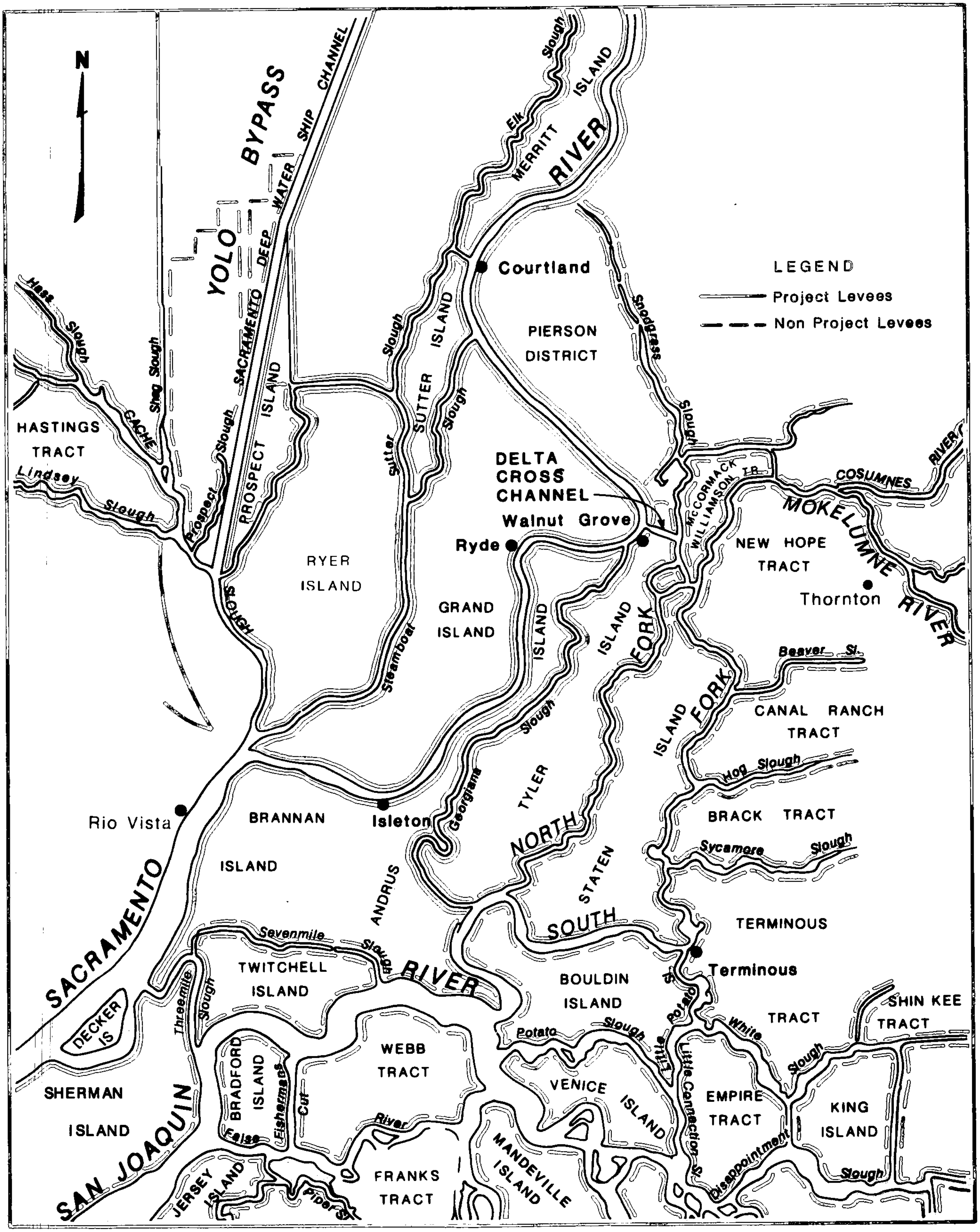


Figure 1–2. Project and Non–Project Levees

The U. S. Bureau of Reclamation (Reclamation) has constructed three major Central Valley Project facilities in the Delta – the Tracy Pumping Plant at the head of the Delta Mendota Canal, the Delta Cross Channel near Walnut Grove, and the Contra Costa Canal . It has a strong continuing interest in Delta water quality, water transfer efficiency, and maintenance of the rich agricultural, recreational, and wildlife resources of the Delta. The Coordinated Operation Agreement (1986) formalized Reclamation's commitment to protect Delta water quality.

The U.S. Fish and Wildlife Service (USFWS) plays a very influential role as expert advisor on fisheries and wildlife impacts and mitigation for other federal agencies, such as USACE and Reclamation, in the planning, construction and operation of public works projects. The USFWS is also responsible for enforcing the Threatened and Endangered Species Act.

The National Marine Fisheries Service (NMFS) and the U. S. Environmental Protection Agency also provide vital environmental advice and guidance. While USACE administers the permit process for fill activities in Delta waterways under Section 404 of the national Clean Water Act, the EPA can prohibit or restrict such fill activities which it determines to have unacceptable impacts on the aquatic system. The NMFS is also responsible for enforcing the Threatened and Endangered Species Act with respect to marine and anadromous species.

The State exercises authority over the Delta through a number of agencies, including the State Lands Commission, The Reclamation Board, the State Water Resources Control Board, the Department of Fish and Game, DWR, the Department of Boating and Waterways, Caltrans, and the Department of Parks and Recreation.

DWR has a broad mandate to facilitate improved flood protection, water quality, water transfer, and other beneficial uses of the Delta through a number of legislative acts.

County and local agencies most directly affect the daily lives of Delta residents, providing police and fire protection, regulating land use, and maintaining nonproject levees.

Any major project contemplated for the Delta must address a broad range of public interests, in part protected through the review and permitting process of the key federal, state, and local agencies. The potential permits required for any proposed improvements in the north Delta study area are summarized in Table 1-1.

DWR will consult with these and all other interested agencies in formulating improvement plans for the north Delta.

The Endangered Species Acts (federal and State) are designed to conserve ecosystems essential to endangered and threatened species and promote conservation of such species. The acts include animals, fish, insects (other than pests), and plants. An endangered species is one in danger of extinction in all or a significant portion of its range; a threatened species is one likely to become endangered. The acts protect endangered species through three major mechanisms: (1) listing of endangered or threatened species, (2) agency consultation and protection responsibilities, and (3) a prohibition of takings of endangered species. One of the major strategies of the acts is to preserve habitat that is critical to the survival of an endangered or threatened species. Any water project that requires a permit from the Corps would trigger the requirements of the Endangered Species Acts, if it were found to endanger a listed species or its critical habitat.

The Fish and Wildlife Coordination Act and related acts express the will of Congress to protect the quality of the aquatic environment as it affects the conservation, improvement, and enjoyment of fish and wildlife resources. Under this act, any federal agency that proposes to control or modify any body of water, or to issue a permit therefor, must first consult with the U. S. Fish and Wildlife Service, the National Marine Fisheries Service, and the California DFG. The Corps' informal practice is to refrain from acting on a permit until the applicant and the fish and wildlife agencies have attempted to identify appropriate mitigation measures.

National Historic Preservation Act (16 USC 470 et. seq.) Section 106 of the National Historical Preservation Act (NHPA) requires federal agencies to evaluate the effects of federal undertakings on historical, archeological, and cultural resources. Agencies are required, within the vicinity of proposed projects, to identify historical or archeological properties, including properties on the National Register of Historic Places, and those that the agency and the State Historic Preservation Office (SHPO) agree are eligible for listing in the National Register. If the federal project is determined to have an adverse effect on National register properties or those eligible for listing, the agency is required to consult with the SHPO and the Advisory Council on Historic Preservation

Table 1–1
Potential Permits

Agency	Permit Description	Permit Conditions
Corps of Engineers (in coordination with U.S. Fish and Wildlife Service and Environmental Protection Agency)	Department of Army Permit (Section 404, Clean Water Act; Section 10, Rivers and Harbors Act)	Permit under Section 404 required for any proposal to discharge dredged or fill material into waters of the United States; or permit under Section 10 required for any proposal to locate a structure or alter navigable waters in the United States, including tidal wetlands.
Department of Fish and Game	Navigation Dredging Permit	Required for any proposal to use suction or vacuum dredging equipment in any river, stream, or lake designated as open.
	Stream or Lakebed Alteration Agreement	Required for any activity that will change the natural state of any river, stream, or lake in California.
Caltrans	Encroachment Permit	Required for any proposal to do work or place an encroachment on or near a State highway or proposal to develop and maintain access to or from any State highway.
	Utility Encroachment Permit	Required for work done by public utility companies providing services, such as gas, electricity, telephone, for most work within the right of way of a State highway.
The Reclamation Board	Encroachment Permit	Required for any activity along or near the banks of the Sacramento and San Joaquin rivers or their tributaries. The Reclamation Board also issues encroachment permits for activity on any "designated floodway" or flood control plan adopted by the Legislature or the Board within the Central Valley.
Air Pollution Control District	Authority to Construct	Required for any proposal to construct, modify, or operate a facility or equipment that may emit pollutants from a stationary source into the atmosphere.
	Permit to Operate	Required for any proposal to operate equipment that emits pollutants into the atmosphere. A Permit to Operate must be obtained from the Air Pollution Control District (APCD) for the area in which the equipment is located. The project sponsor may apply for the permit only after obtaining an Authority to Construct from the APCD and completing the construction or modification according to the terms of the Authority to Construct.
State Water Resources Control Board, Division of Water Rights	Permit to Appropriate Water	Required for proposal to divert water from a surface stream or other body of water for use on nonriparian land or any proposal to store unappropriated surface water seasonally.
Department of Water Resources, Division of Safety of Dams	Approval of Plans and Specifications and Certificate of Approval	Required for any proposal to constrict or enlarge a dam or reservoir.
State Lands Commission	Dredging Permit	Required for any proposal to dredge in State-owned swamps, overflows, marshes, tidelands and submerged lands or in the beds of navigable waters where the State has mineral rights.

to develop alternatives or mitigation measures to allow the project to proceed.

Interagency Ecological Studies

In addition to the Delta protective measures discussed above, an Interagency Ecological Study Program (IESP) was created in 1970 to determine the effects of SWP and CVP operations on the Bay/Delta ecological system and to find a means of eliminating, reducing, or offsetting any adverse impacts. The program is being conducted by DFG, DWR, the U. S. Fish and Wildlife Service (USFWS), Reclamation, the U. S. Geological Survey (USGS), and SWRCB. Ecological studies are an integral part of the mitigation needed for the estuary. Under the terms of an Interagency Memorandum of Agreement executed on July 13, 1970, the agencies have agreed to jointly pursue activities that will provide the ecological studies necessary for a thorough understanding of the San Francisco Bay-Delta estuary. The program is divided into several parts:

Fish Studies. These studies provide information on the fisheries resources in the San Francisco Bay-Delta area. The primary focus of the studies have been striped bass and salmon. The current programs include:

- an annual egg and larvae survey to index numbers, growth, and survival of the striped bass spawn;
- a summer tow net program to index the number of striped bass in the Delta–Suisun Bay area when the average size of the young of the year is 1.5 inches;
- a mid–water trawl program to index the number of striped bass during the fall and winter of their first year;
- a mark–recapture program to develop estimates of the numbers of adult striped bass by sex and age;
- a study of the numbers of striped bass egg and larvae entrained into Clifton Court Forebay;

Water Quality Studies. These studies consist of monitoring programs, mathematical modeling efforts, and special studies focusing on food relationships in the San Francisco Bay/Delta. Some current studies include:

- a routine sampling program for zooplankton and *Neomysis*; and
- the development and refinement of a mathematical model of phytoplankton dynamics in the Delta.

San Francisco Outflow Study. This is a study designed to characterize the aquatic biota and circulation patterns in San Francisco Bay. The data are being used in analyzing the impact of the timing, duration, and magnitude of fresh–water flows on San Francisco Bay. Activities include:

- a monthly tow net sampling program to sample the temporal and spatial distribution of various species in the Bay;
- a study to analyze the correlations between fresh water inflows and salinity at various locations in San Francisco Bay;
- field programs to collect velocity, salinity, temperature, water level, and wind data. These data will be used to calibrate and verify models of the hydrodynamics of San Francisco Bay; and
- a monitoring program designed to identify selenium sources and sinks in the San Francisco Bay–Delta.

Fish Facilities and Related Studies. These studies evaluate sources of fish losses at the Skinner Fish Protective Facility, Clifton Court Forebay, and other SWP facilities in the Delta. The data are used to develop measures to reduce losses. Current activities include:

- an evaluation of the Skinner Fish Facility operational criteria;
- evaluations of predation losses of striped bass and chinook salmon in Clifton Court Forebay; and
- a monitoring program to document the fishery resources, channel water quality, land vegetation, and soil/vegetation relationships, before and after installation of facilities in Suisun Marsh to enhance water quality.

Other Studies

Studies other than those under the direction of the Interagency Ecological Study Program include:

D–1485 Water Quality Monitoring Program. DWR regularly conducts a compliance monitoring program to ensure that the protective standards in Water Rights Decision 1485 are met. This has also provided important information for environmental assessment and understanding. The program has three components:

- Bay/Delta Compliance – This component comprises surface water quality monitoring, which includes the discrete sampling of a series of physical, biological, mineral, and chemical parameters. Approximately 30 stations are sampled once a month. If the Delta Outflow Index at Chipps Island is projected to fall below 10,000 cfs, the sampling rate is increased to a biweekly schedule. On the alternating week of the discrete program, a continuous monitoring run is made with a boat carrying flow-through water quality equipment. The data are recorded on a strip chart at the rate of one instantaneous reading per minute per parameter.

- Continuous Multiparameter Network – This component consists of surface water quality continuous monitoring at six fixed sites in the Delta. Approximately 10 parameters are monitored at each site. Also, continuous monitoring of electrical conductivity is required at nine sites.
- Suisun Marsh Monitoring Plan – This component is designed to meet the monitoring requirements of D-1485 and Bay Conservation and Development Permit 35–78. The data generated by this program include continuous electrical conductivity, water stage data collected at seven channel stations, and soil salinity information from an electrical conductivity network at 18 diversion points in the marsh. The purpose of this program is to examine the relationship between the quality of the channel waters and salinity of the soil to which it is applied.

Salmon Management Planning Team. This task force was voluntarily established by DWR, DFG, USFWS, Reclamation, and the National Marine Fisheries Service during Phase I of the SWRCB Bay–Delta Hearings to develop an overall salmon management plan for the Central Valley. The group has been subdivided into three subcommittees, based on geographic areas. They are:

- Sacramento River Salmon Committee – This committee is charged with evaluating measures to improve the survival salmon smolts in the Sacramento River upstream of the Delta. Some of the current activities include:

  – completion of a salmon model to evaluate the impact of various environmental factors on the ocean salmon population;

  – evaluation of the benefits of a variety of projects that might result in enhanced production and survival of salmon in the upper Sacramento River and tributaries.

- Delta Salmon Committee – This committee is evaluating measures to improve the survival of salmon smolts when they are in the Delta. Some of the current activities include:

  – studies examining the relationship between survival of smolts and such factors as water temperature, flow, export pumping, reverse flows, and water diverted through the cross-channel;

  – evaluation of operational and physical means of reducing losses of salmon smolts.

- San Joaquin River Salmon Committee – This committee is evaluating measures to improve the survival of smolts as they move down the San Joaquin River before reaching the Delta. Some of the current activities adjacent to the Delta include:

  – a mark and recapture study designed to compare the survival rates of those salmon smolts drawn down Old River to those salmon smolts drawn down the San Joaquin River. These data will be directly applicable in the evaluation of facilities in the south Delta;

EPA San Francisco Bay Estuary Project. As part of the federal Water Quality Act of 1987, the Environmental Protection Agency established the National Estuary Program to improve and protect the resources of the nation's estuaries. Within this program, the San Francisco Estuary Project (SFEP) addresses the specific needs of the San Francisco Bay/Delta area. SFEP objectives include:

- merging information about environmental and public health with social and economic factors;
- providing the impetus for developing united and effective management of the Bay/Delta;
- developing a "Comprehensive Conservation and Management Plan" to restore and maintain the chemical, physical, and biological integrity of the Bay/Delta; and
- developing a plan which addresses point and nonpoint sources of pollution, including a priority rating and a schedule of corrective actions.

To aid SFEP in reaching these objectives, a SFEP Technical Advisory Committee was formed to provide technical expertise.

Interagency Delta Health Aspects Monitoring Program. This program was developed in 1983 to address aspects of water quality in the Delta that were pertinent to public health. The objectives of the program include the development of data that will be used to:

- plan for control and treatment of the identified constituents by the State Water Contractors;

- evaluate the relative health benefits of various Delta alternative facilities;
- support various mathematical modeling activities; and
- support various water supply planning activities.

State Water Project History and Purpose

As the growth of California accelerated, particularly after World War II, State officials perceived a need for a water resources development system far more extensive than provided by the federal Central Valley Project.

By 1951, State water planners outlined the fundamental elements of what would become the State Water Project (SWP). Some important milestones in development of the SWP were passage of the Burns–Porter Act (authorizing the Project's initial facilities) in 1959, approval of the California Water Resources Development Bond Act in 1960, the beginning of construction of Oroville Dam in 1962, and the initial operation of the California Aqueduct in 1968.

The major facilities of the SWP, constructed mainly in the 1960s and early 1970s, are shown in Figure 1–3. Surplus water from the Feather River watershed and the Sacramento–San Joaquin River Delta is captured and conveyed to areas of need in the San Francisco Bay area, the San Joaquin Valley, and Southern California.

Thirty agencies throughout the State have contracted to eventually receive 4.23 MAF of water a year, to be delivered as their needs develop. The existing facilities can supply about 2.3 MAF, enough to meet present needs. Additional facilities are planned to increase the supply.

Besides contractual obligations and agreements for water supply, the SWP is required by law to provide salinity control in the Delta. Recreation and fish and wildlife enhancement are also among the Project's authorized purposes.

The Existing State Water Project and Related Mitigation

The SWP provides numerous benefits to the people of California, including water supply, flood control, recreation, and energy production.

SWP recent entitlements and other deliveries have ranged from 2.0 to 3.0 MAF annually. In addition, the SWP has provided flood control, recreation, and hydroelectric benefits. Oroville Dam has prevented millions of dollars in flood damage. Recreational use continues to increase, including fishing in the California Aqueduct and the various SWP reservoirs. Today's annual recreation user days exceed 7 million. Hydroelectric power generation at SWP pumping–generating plants offsets the need to burn fossil fuels and reduces pollution. Some 3 billion kWh are generated each year. Tables 1–2 and 1–3 summarize the benefits through 1987.

The California Aqueduct begins at the Banks Pumping Plant and extends 444 miles. It is the principal conveyance facility of the overall project, which now includes 22 dams and reservoirs, 8 hydroelectric power plants, and 17 pumping plants. Except for the Banks and Pearblossom pumping plants, all pumping plants along the California Aqueduct have the planned pumping units installed. Additional pumps at both plants are scheduled for operation in 1991. The Burns–Porter Act also authorized unspecified additional future storage facilities, facilities to transfer water across the Sacramento–San Joaquin Delta, and facilities to remove drainage water from the San Joaquin Valley.

As required by the California Water Resources Development Bond Act, Water Code Section 12934(d)(2), the California Aqueduct system has a capacity of not less than 2,500 cfs at all points north of the northern boundary of the County of Los Angeles in the Tehachapi Mountains near Quail Lake and a capacity of not less than 10,000 cfs at all points north of San Luis Reservoir.

Lake Oroville, the main storage facility, is situated on the Feather River in Butte County. SWP facilities at Oroville are operated for flood control, power generation, instream fisheries, along with water supply for local areas, the Delta, and export. Three upstream reservoirs on the headwaters of the Feather River are operated for local water supply, recreation, and instream fisheries. Water released for fish and the other purposes, together with irrigation return flows, goes down the Feather and Sacramento rivers and then into the network of channels in the Delta. Releases from the Oroville facilities contribute to Delta uses, Delta salinity control, and export needs out of the Delta.

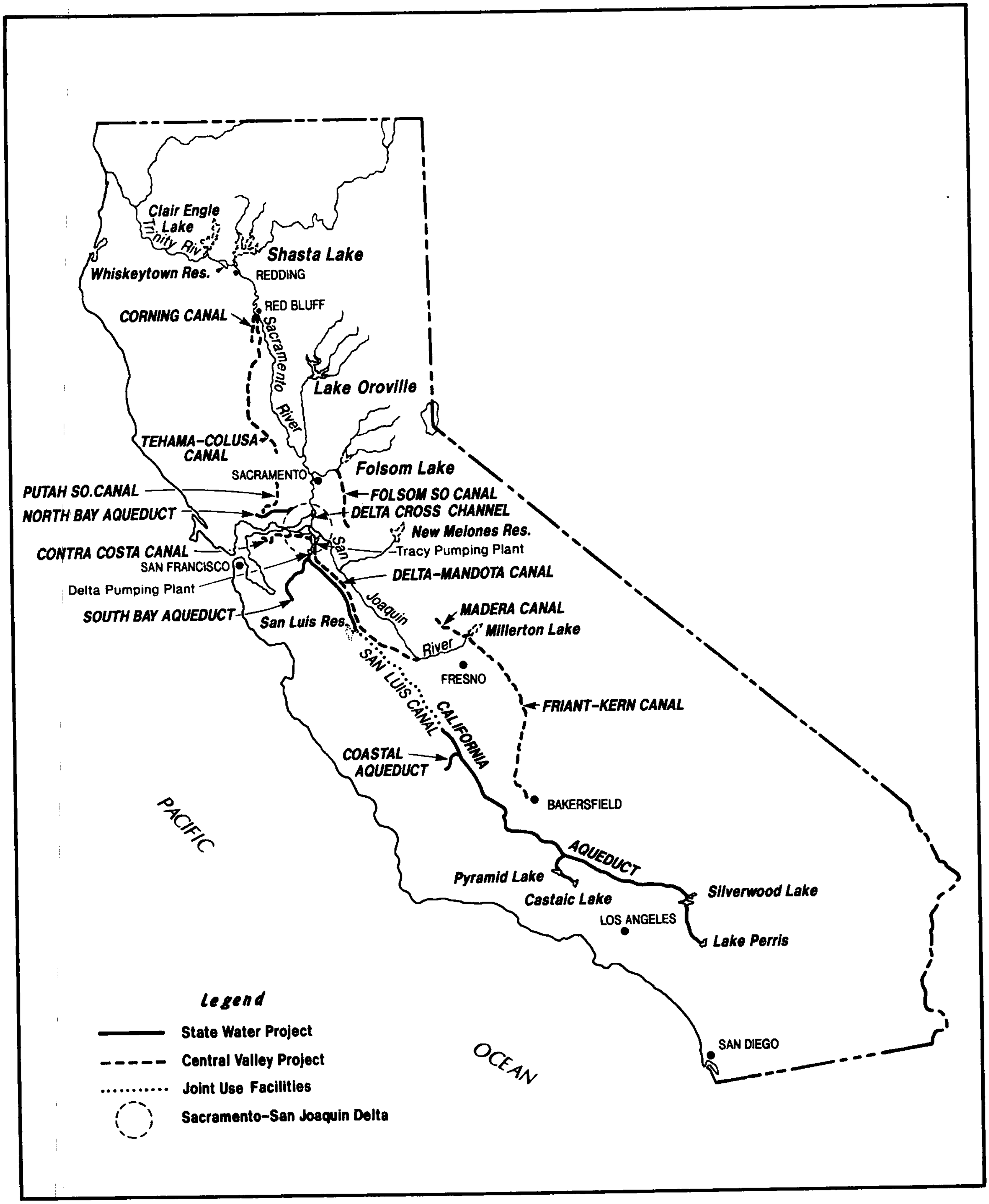


Figure 1–3. Major Features of the SWP and CVP

Table 1-2

SWP Accomplishments Through 1987

Water Delivered (AF)							
	Entitlement Water			Other Deliveries			
				Surplus			
Year	Municipal & Industrial Use	Agricultural Use	Total	Municipal & Industrial	Agricultural	Other Water	Total Delivery
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1962						18,289	18,289
1963						22,456	22,456
1964						32,507	32,507
1965						44,105	44,105
1966						67,928	67,928
1967	5,747	5,791	11,538	0	0	53,605	65,143
1968	46,472	125,237	171,709	10,000	111,534	14,777	308,020
1969	34,434	158,586	193,020	0	72,397	18,829	284,246
1970	47,996	185,997	233,993	0	133,024	38,080	405,097
1971	85,286	272,054	357,340	2,400	293,619	44,127	697,486
1972	181,066	430,735	611,801	22,205	401,759	73,127	1,108,892
1973	293,824	400,564	694,388	3,161	293,255	43,666	1,034,470
1974	418,521	455,556	874,077	4,753	412,923	48,342	1,340,095
1975	641,621	582,369	1,223,990	21,043	601,859	67,170	1,914,062
1976	818,588	554,414	1,373,002	32,488	547,622	116,962	2,070,074
1977	280,919	293,236	574,155	0	0	390,176	964,331
1978	742,385	710,314	1,452,699	3,566	13,348	122,916	1,592,529
1979	690,659	969,237	1,659,896	66,081	582,308	189,396	2,497,681
1980	730,545	799,204	1,529,749	19,722	384,835	48,590	1,982,896
1981	1,057,273	852,289	1,909,562	12,000	896,428	283,849	3,101,839
1982	928,721	821,303	1,750,024	0	215,873	155,820	2,121,717
1983	483,499	701,370	1,184,869	0	13,019	188,596	1,386,484
1984	725,925	862,694	1,588,619	3,663	259,254	387,505	2,239,041
1985	992,538	1,002,915	1,995,453	9,638	298,034	408,904	2,712,029
1986	998,611	997,025	1,995,636	2,595	34,025	197,471	2,229,727
1987	1,096,368	1,033,718	2,130,086	6,949	107,958	385,264	2,630,257
Total	**11,300,998**	**12,214,608**	**23,515,606**	**220,264**	**5,673,074**	**3,462,457**	**32,871,401**

Lake to Castaic Lake, northwest of Los Angeles; the East Branch delivers water to the Antelope Valley and terminates at Lake Perris, in Riverside County.

State Water Project Supply Contracts. DWR has long-term water supply contracts to deliver specified annual amounts of water to each of 30 contracting agencies. These contractors are in the Feather River basin, Bay area, San Joaquin Valley, Central Coastal area, and Southern California. The maximum annual entitlements for all contractors total about 4.2 MAF. This represents the maximum water that would be delivered by the State to its contractors under full contract conditions. To deliver this maximum amount of water would require the full capacity of 10,300 cfs at the Banks Pumping Plant, as well as other future water development features, including the NDP.

Water contracts establish annual entitlements and procedures for allocating deficiencies, surplus water deliveries, and payment. In general, the annual entitlements follow buildup schedules, increasing each year until the maximum annual entitlement is reached. A contracting agency may request that project water be made available in annual amounts greater or less than scheduled annual entitlements, but not greater than its maximum annual entitlement.

If, during any year, the supply of project water exceeds the total requested water deliveries for annual entitlements of all contractors and necessary carryover storage for that year, the State can sell and deliver such water as surplus water. Requests for surplus water have a lower priority than entitlement requests.

A temporary shortage of water supply can occur in any year when a drought or other condition reduces project water available to less than the total requests for annual entitlements of all contractors for that year. In such an event, the State Water Project is operated to reduce deliveries of that year's annual entitlement used for agricultural purposes by a percentage not to exceed 50 percent in any one year or a total of 100 percent of yearly annual entitlements in any seven consecutive years. If necessary, further reductions will be made to all deliveries, regardless of use, and the reduction will be in proportion to the entitlement.

The annual entitlements and the maximum annual entitlements of all contractors will be reduced proportionately under the following specific conditions:

- The State is unable to build enough additional conservation facilities to prevent a reduction in minimum yield.
- There is a reduction in the minimum project yield for any other reason.

In both cases, preventive or remedial measures by DWR will be considered before the shortage is applied. If a shortage is applied, the sum of the revised maximum annual entitlements of all contractors will equal the reduced minimum project yield.

State Water Project Operation

Operation of the State Water Project is governed by physical and institutional constraints. Physical factors limiting SWP operations include:

- available water supply, SWP demands, and delivery capabilities
- power operations
- hydraulic constraints and Banks Pumping Plant capacity

These governing factors are discussed in the following sections. Other institutional constraints were discussed in the Related Delta Protective Measures section.

Available Water Supply and Delivery Capabilities. Availability of water supplies at the Delta varies with natural conditions and upstream development. Natural hydrologic variations cause extreme fluctuations in monthly and yearly inflows. Winter floods produce Delta flow rates of several hundred thousand cfs, while summer conditions can decrease rates to a few thousand cfs. The total annual volume of inflow can also vary substantially. Unimpaired annual volumes range from less than 7 MAF in critical years to more than 70 MAF in wet years.

Upstream development has occurred from both local and project facilities. Use within the local area has priority over project use through area of origin laws; therefore, local development will directly decrease project supplies as it occurs. By 2000, existing project firm yield supplies are projected to decrease by 300,000 AF. Upstream development will contribute to future shortages if proper solutions are not found. However, other factors in the service areas will also add to the frequency and severity of such shortages. Even with extensive planned conservation efforts, urban water demands will increase, primarily because of population increases. This is further complicated by the fact that a portion of Colorado River supplies used by southern California for many years will be diverted to Arizona.

Dependable water supplies from SWP facilities are now about 2.3 MAF per year. About half this water comes from Lake Oroville on the Feather River; the rest is developed from surplus flows in the Delta, some of which are re-regulated in San Luis Reservoir.

The amount of surplus Delta water supply is affected by the volume of outflow required to meet water quality standards in the Delta established by the SWRCB. Existing standards are specified in Decision 1485, adopted in 1978 (see discussion under Related Delta Protective Measures).

The measure of delivery capability for the SWP was founded on the concept of "firm yield" operation. Defined as "minimum project yield" in SWP water contracts, firm yield is the dependable annual water supply that can be made available without exceeding specified allowable reductions in deliveries to agriculture during extended dry periods.

Beginning in 1987, contractors requests for delivery of entitlement water exceeded the firm yield of existing facilities. Recently, DWR has worked with the major contractors to increase the SWP's average annual deliveries. This is done by relaxing its minimum reservoir carryover storage requirements to permit increased deliveries in all but the driest years.

Short-range decisions for the operation of SWP facilities are made with an annual "rule curve." The rule curve provides a rational means to decide how much water may be delivered in a given year and how much should be left in storage as insurance to protect against subsequent dry periods. Until recently, the procedure used to develop the annual rule curve was designed to assure a high probability of meeting future delivery schedules. This resulted in relatively high fall storage target levels for Lake Oroville and the State portion of San Luis Reservoir, and quite often delayed approval of water delivery requests until late in the water-producing season.

As the contractors' annual requests for entitlement water continued to rise, DWR became increasingly aware that alternative rule curve procedures could permit larger deliveries in average or wet years without substantially reducing delivery capability during dry years. With the concurrence of the SWP contractors, one such alternative rule curve procedure was adopted, on a trial basis, for use in 1986. The 1986 rule curve procedure relaxed the requirements for fall carryover storage somewhat, permitting larger deliveries in most types of years, but at the possible expense of reduced deliveries in the driest years. The modified rule curve permits approval of a reasonable annual delivery early in the water-producing season without jeopardizing the average dry-period supply that would be available during a recurrence of the historic 1928-34 drought period.

Further study and information provided by the water contractors led, in 1987, to a lower schedule of target storage, and in 1988 to a calculation of delivery by formula based on carryover storage only.

In 1989, the rule curve was renamed the "water delivery risk analysis" (WDRA); the "Four Basin Index, which is the unimpaired runoff from streams entering the Sacramento Valley became the "Sacramento River Index" (SRI); and "conservation storage" was interpreted to include: 1) Lake Oroville, 2) the State's share of San Luis Reservoir, and 3) the balance owed to DWR by Reclamation under the COA.

The 1989 WDRA used the same criteria as in 1988 for development of the risk analysis curve, but the procedure for determining delivery approvals was changed. Delivery approvals for 1989 were based on a forecast of the SRI, with a probability of exceedence of approximately 90 percent instead of 99 percent for the December forecast. The 99 percent exceedence level forecast was used for March, April, and May forecasts.

State Water Project Power Operations. DWR is one of the largest publicly-owned electric systems in the United States. Since April 1983, DWR has operated as a bulk power agency. As such, DWR operates a mix of owned, contracted, and purchased power resources to meet SWP needs via contracted transmission capacity. This requires that DWR maintain a reliable power system.

Due to DWR's unique ability to control its pumping loads, DWR will always be a major purchaser and seller of power in the west. Managing its water and power resources will result in lowering the cost of delivered water to the water contractors.

In addition to energy requirements, DWR must consider electrical capacity requirements—the maximum demands for electrical power during given periods of time. Since DWR has flexibility in regulating SWP electrical power load, the project is operated to minimize pumping requirements during on-peak periods, when capacity and energy costs are greatest. Thus, SWP maximum electrical capacity requirements occur during off-peak periods (nights, weekends, and holidays).

SWP power requirements can vary significantly, depending on the balance of water supply and water demand in a given year. Dry conditions in northern California reduce the supply of water available for delivery and decrease power requirements if the SWP cannot deliver full entitlement requests. Power requirements also decrease if hydrologic conditions or actions by local water agencies reduce demands in the San Joaquin Valley or Southern California.

Hydraulic Constraints and Banks Pumping Plant Capacity. Hydraulic constraints can limit monthly maximum exports of the SWP. The constraints are related to:

- volume of Clifton Court Forebay
- forebay inlet gate size and location
- capacity of southern Delta channels
- flows in the San Joaquin River
- tidal fluctuations at the inlet gate

Clifton Court Forebay storage enables a high use of off-peak power at the Banks Pumping Plant. Inflows to the forebay are governed by tidal fluctuations, which average 3.7 feet daily. Five radial gates at the southeastern corner of the forebay are open during high tides and closed during low tides. Operational procedures for the inlet gates consist of minimizing the drawdown effects of the diversions at all tide levels.

South Delta channels were not designed for project operations; therefore, they limit the amount of water that can be pumped from the south Delta without eroding the channels and levees. Water levels in south Delta channels are sensitive to SWP and CVP diversions. The drawdown effects are of concern to local agricultural diverters and have been studied as part of the discussions and negotiations between the SDWA, Reclamation, and DWR. Water supply and quality issues in the south Delta are discussed at the beginning of this chapter.

Banks Pumping Plant and Clifton Court Forebay play a key operational role because they are at the head of the aqueduct system.

The physical capability of the Banks Pumping Plant will increase from 6,400 to 10,300 cfs with the four additional pumps now under construction. However, the maximum monthly export rate will probably be less than 10,300 cfs because of hydraulic constraints. DWR estimates the maximum average monthly rate with these constraints to be about 6,680 cfs and 7,300 cfs in some winter months when San Joaquin River flows are high. The estimated yield increase of the four additional pumps with the 7,300 cfs maximum is 57,000 AF per year. This is an increase in yield of less than 3 percent over the existing project capability.

Public Scoping Issues

The scoping process for this project was carried out in two stages. The first stage consisted of public scoping meetings held in the spring of 1987. The second stage consisted of the formal steps of soliciting input from concerned federal and state agencies and individuals as required by the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA).

Stage One – Scoping Meetings

Stage One was initiated on July 31, 1987, when DWR mailed meeting announcements to individuals and agencies who have in the past expressed an interest in Delta activities. In addition, a public notice was printed in eight major newspapers. Meetings were held on August 25, 1987 in Walnut Grove and September 11, 1987 in Sacramento. Several articles appeared in the local press and trade bulletins before and after the scoping meetings were held. At both scoping meetings, DWR representatives explained the background of the North Delta Water Management Program. Participants asked questions, made comments, and filled out questionnaires.

The first stage scoping process was documented in a draft report, *North Delta Water Management Program, a Draft Report on Public Involvement and Identification of Issues*, dated February 1989.

Stage Two – Formal Scoping Process

During stage two of the scoping process, DWR carried out the formal actions required by CEQA and NEPA. To comply with state regulations, DWR issued a Notice of Preparation (NOP) on May 17, 1989 and the Corps of Engineers published a Notice of Intent (NOI) on May 19, 1989 in the Federal Register. In addition, on May 17, 1989, the Corps mailed 1800 copies of a Public Notice to North Delta Land owners and various state, federal and local entities. All documents requested public input.

Results of the scoping process were documented in a final report titled *North Delta Water Management Program, Scoping Report for Environmental Impact Report and Environmental Impact Statement,* dated November 1989. The significant issues identified in the scoping process are summarized in Appendix A.

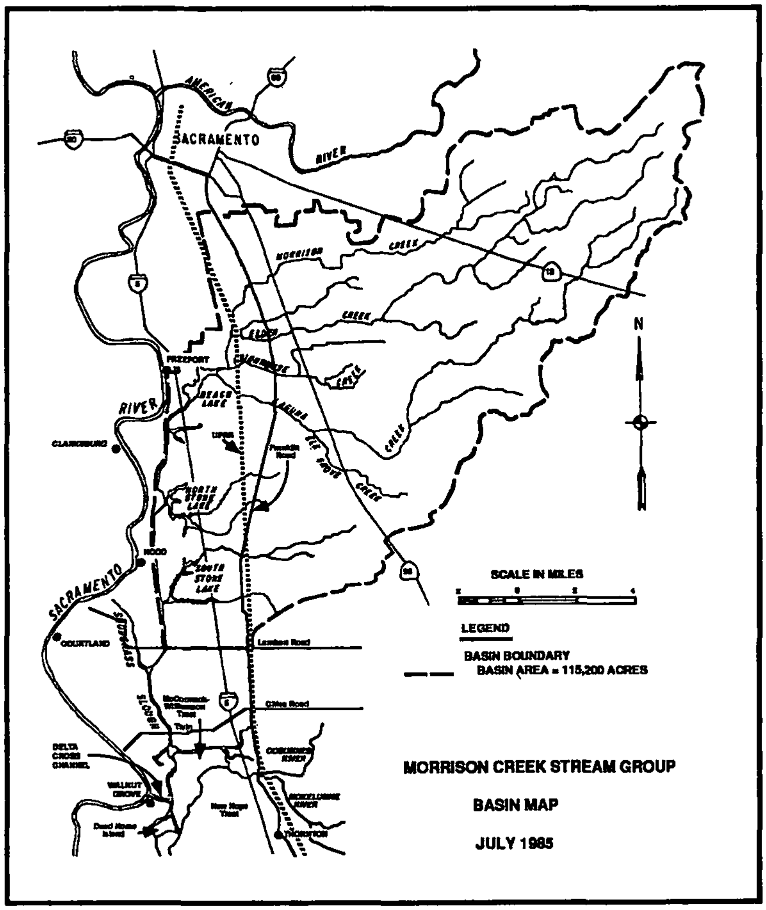


Figure 2–2. Morrison Creek and Tributaries

Reduce Reverse Flow

The expression "reverse flows" is used to characterize a Delta problem that stems from the lack of capacity in certain channels. Water supplies for export by the CVP and SWP are obtained from surplus Delta flows, when available, and from upstream reservoir releases, when Delta inflow is low and surplus flows are unavailable. Most of these surplus flows and releases enter the Delta via the Sacramento River and then flow by various routes to the pumps in the southern Delta. Some of these flows are drawn to the SWP and CVP pumps through interior Delta channels, facilitated by the CVP's Delta Cross Channel. Unfortunately, because the channels aren't large enough, insufficient amounts of water pass through the northern Delta channels.

The remaining water flows down the Sacramento River to its confluence with the San Joaquin River in the western Delta. When fresh–water outflow is low, water in the western Delta becomes brackish because it mixes with saltier ocean water entering as tidal inflow. This water is drawn upstream (reverse flow) into the San Joaquin River and other channels by the pumping plants. Reverse flow disorients migratory striped bass, salmon, and steelhead. Reverse flow further increases the impacts on fish by pulling eggs, small fish, and fish food organisms from the western Delta nursery area into the pumping plants. The massive amount of water driven in and out of the Delta by tidal action dwarfs the actual fresh–water outflow and reverse flow and considerably complicates the reverse–flow issue.

Reverse flow could be moderated or eliminated by increasing the transfer efficiency of the northern Delta channels. Also, water supply for the SWP would be considerably increased. Currently, during the operational periods that cause reverse flow, more water than is needed for export must be released from project reservoirs to repel intruding sea water and to maintain required water quality in western Delta channels and meet export quality standards. The

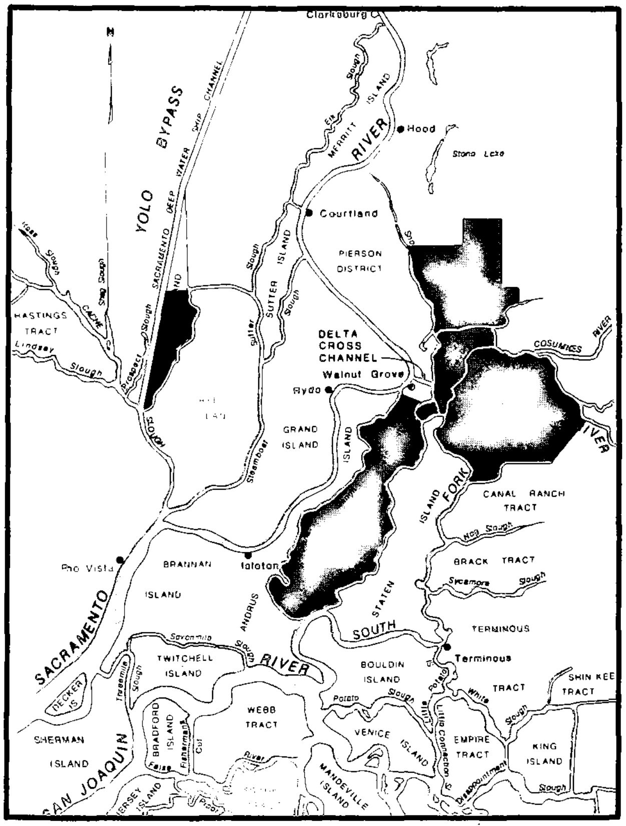


Figure 2–3. Islands Flooded, February 1986

amount of extra outflow required is substantial (Figure 2–5) .

A primary objective of the NDP is to reduce reverse flows and the resultant adverse impacts. This could be achieved by improving the conveyance capacity of north Delta channels. A larger portion of the water drawn by the CVP and the SWP would be drawn along the desirable path through the north and south forks of the Mokelumne and then through the San Joaquin River system (see Figure 2–6).

With a reduction in reverse flow, upstream fresh water storage could be used more efficiently to repel salt water to meet Delta protective standards and export water quality needs. DWR estimates that the SWP could gain from 200 to 400 TAF/YR in dependable supply from the added efficiency of the NDP.

Improve Water Quality

Reduction or elimination of reverse flows will improve the quality of water in the Delta. Water quality in the Delta is presently being protected by many standards established by the SWRCB and by the Coordinated Operation Agreement between Reclamation and DWR. In addition,various contracts with Delta users also include levels of water quality protection. The standards are periodically reviewed by the SWRCB to protect beneficial uses of the water supplies. However, water quality conditions can be further improved by reducing reverse flow.

A graph of the Sacramento River salinity gradient, Figure 2–7 illustrates the undesirable nature of the reverse flow path. The Delta Cross Channel, Georgiana Slough, and Threemile Slough leave the Sacramento River in the good quality portion of the gradient and can provide a desirable source of water supplies. The reverse flow path continues into the portion of the salinity gradient near the western end of Sherman Island, about 50 miles from the Golden Gate. In this area, the water is blended with water having chloride levels of more than 1,000 parts per million.

Delta water also contains precursors of trihalomethanes (THMFPs), suspected carcinogens produced when chlorine used for disinfection reacts with natural substances during the water treatment process. Dissolved organic compounds that originate from decayed vegetation act as precursors by providing a source of carbon in trihalomethane formation reactions. During periods of reverse flow, bromides from the ocean intermix with Delta water at the western edge of Sherman Island. When bromides are present in water along with organic THM precursors, trihalomethanes are formed that contain bromine as well as chlorine.

Drinking water supplies taken from the Delta are treated to meet current THM standards; however, more restrictive standards are being considered. If adopted, tighter standards will increase the cost and difficulty of treating present Delta water sources. By

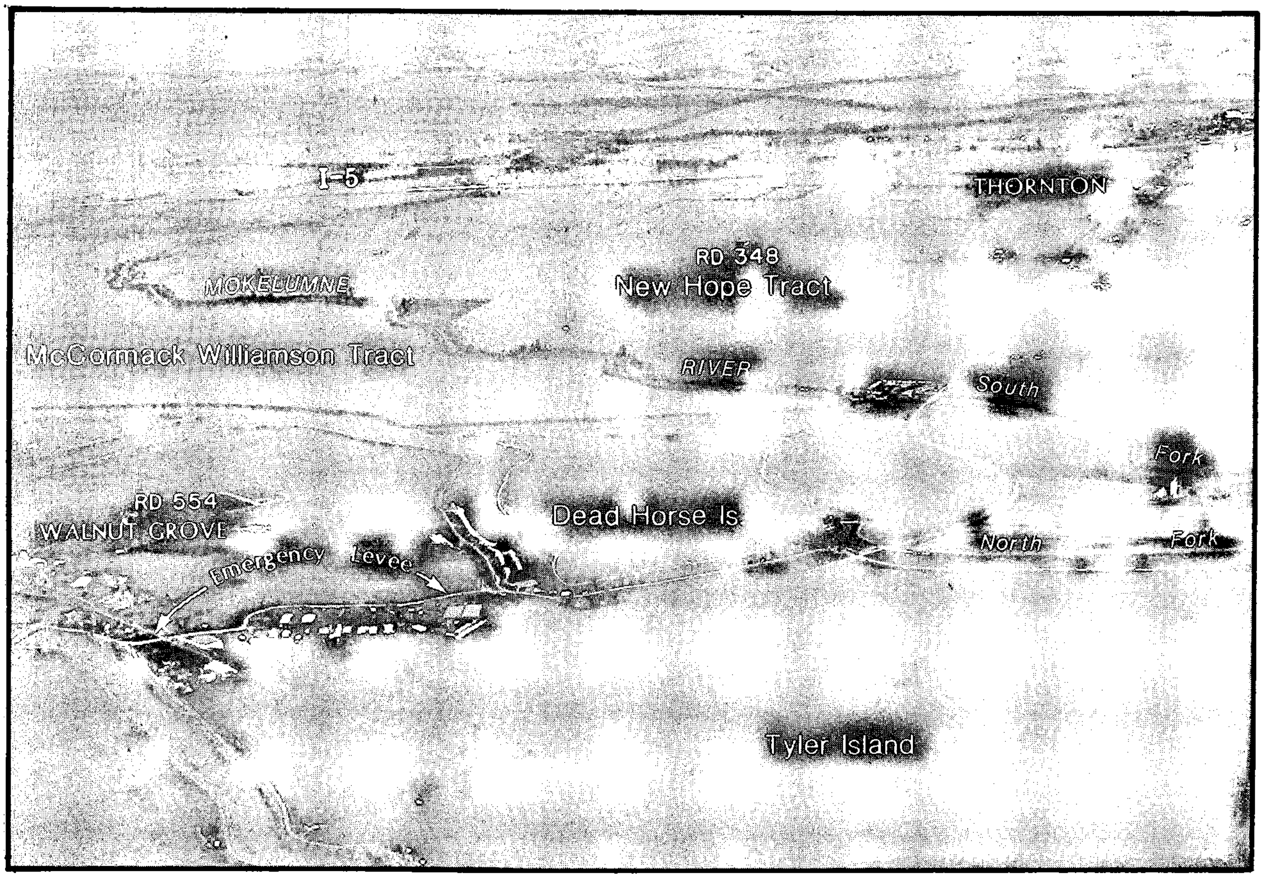


Figure 2–4. February 1986 Flooding – Looking Northward

reducing reverse flow, export water would follow a more direct path, avoiding ocean bromides and reducing THM problems.

The degree to which water quality could be improved by the NDP depends on the course of action selected. Project alternatives and phases being considered are described in Chapter 3.

Reduce Fishery Impacts

Existing measures taken to improve and protect the Delta fishery include the following:

- Delta Pumping Plant agreement;
- Protection standards for flow, quality, export and operation of the Delta Cross Channel;
- Protective laws for fish and wildlife; and
- Funding for environmental research and monitoring.

Additional improvements can be provided by reduction of reverse flows, which create an undesirable environment for migrating fish, young striped bass, and fish food organisms. Reverse flows increase direct impacts on fish at the Skinner Fish Facility, primarily because striped bass larvae and juveniles are in high concentrations where reverse flow exists in the Sacramento River and west Delta. During reverse flow conditions, higher concentrations of fish are carried to State and federal export facilities. Also, young striped bass that have been spawned in the lower San Joaquin River between Antioch and Venice Island (within the area of reverse flow) are drawn to the pumping plants.

As previously noted, reverse flows and the corresponding fishery impacts could be moderated or eliminated by increasing the transfer efficiency of north Delta channels.

Fishery conditions could also be improved by constructing setback levees. A new setback levee would provide more shoreline, and the existing levee would be breached in some areas to create berms for additional riparian habitat. This could include temporary

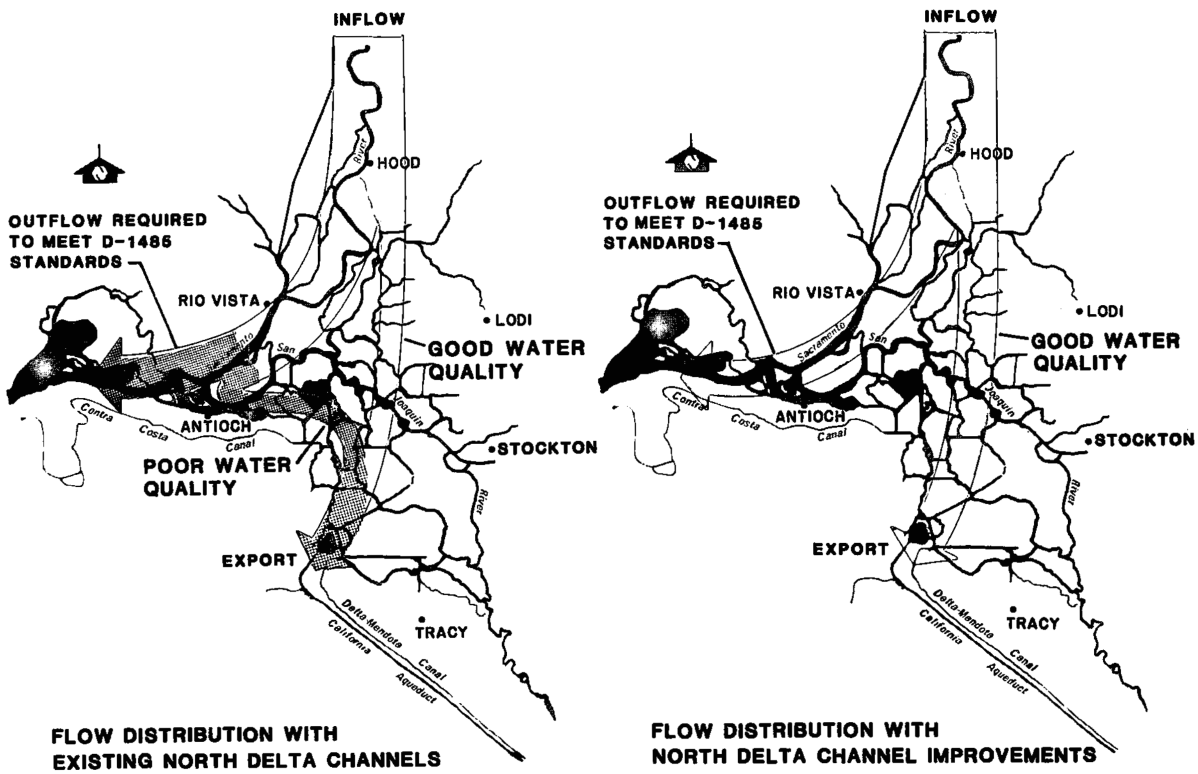


Figure 2-5. Flow Distribution, With and Without Reverse Flow

closure of the Delta cross channel gates to accommodate periods of high fish density.

Improve Project Efficiency and Water Supply Reliability

In addition to the need for improved water transport conditions in the north Delta, north Delta hydraulic improvements will be needed to meet future local and statewide water demands. The State's yearly net water needs by 2010 are projected to reach 35.6 million acre-feet (MAF). Improved north Delta hydraulics, an enlarged forebay, and a permit for SWP to pump 10,300 cubic feet per second (cfs) would add operational efficiency, water supply reliability, and operational flexibility to both the SWP and the CVP.

Improve Navigation

Narrow, shallow channels restrict navigation in a number of north Delta channels, particularly the Mokelumne River and the south fork of the Mokelumne River. Deepening and widening these channels, as well as removing some snags, will improve access and safety. Barge access to the levees will facilitate more cost effective levee maintenance operations.

Enhance Recreational Opportunities

Various components of the NDP would enhance recreational opportunities in the north Delta. Proposed channel improvements could lead to additional recreational development. Dredging would make accessible some scenic stretches of channel. Levee setbacks would create berm islands and additional shoreline for riparian habitat and recreation.

Details of potential recreational development can be found in the *Recreation Facilities Plan for North & South Delta* (Ebasco, March 1988). The study presents conceptual- level cost estimates for several suggested recreation areas that can be developed in conjunction with the NDP. The recreational development plans are consistent with provisions of the Davis–Dolwig Act, which requires consideration of recreational facilities as part of any new SWP facility.

Enhance Wildlife Habitat

Setback levees and wide berms offer an excellent opportunity to develop habitat for wildlife. The land would be publicly owned and available for non–intensive recreation. Setback levees are the primary tool for avoidance mitigation and for providing areas for replacing or enhancing fish and wildlife values.

The necessity for levee maintenance and inspection has eliminated much of the vegetation from the levees in the Delta. Shallow marsh, riparian forest, and shaded riverine aquatic cover have been greatly reduced. The NDP can avoid impacts to these habitats and at the same time create additional habitat by setback levee construction. Desirable attributes include extensive shallow, low–velocity areas that have abundant vegetative cover in and over the water. The creation of uniformly deep, open water habitats or extensive high–velocity aquatic areas is not desirable. Whether such berms should be planted with trees and shrubs or allowed to revegetate naturally would be determined on a site–by–site basis.

The purchase of additional land adjacent to or near the project area for mitigation can also add to the overall enhancement of the area for fish and wildlife.

Project Components

Project components being considered to meet the objectives of the NDP are discussed below. Specific descriptions of project alternatives are explained in detail in Chapter 3.

Dredging

Dredging the existing channels is the most economical and direct way of increasing hydraulic capacity. Enlarging the cross sectional area would provide significant flood control benefits.

Setback Levees

Setback levees are new levees on one side of the channel, running parallel to the old levee but set back on the land side an appropriate distance. A new channel would be created between the new and old levee. The old levee and existing channel would remain. Setback levees would probably alternate from one side of the channel to the other depending on existing vegetation, soil conditions, distance to borrow sites and location of structures such as homes, silos, and marinas.

Levee Improvements

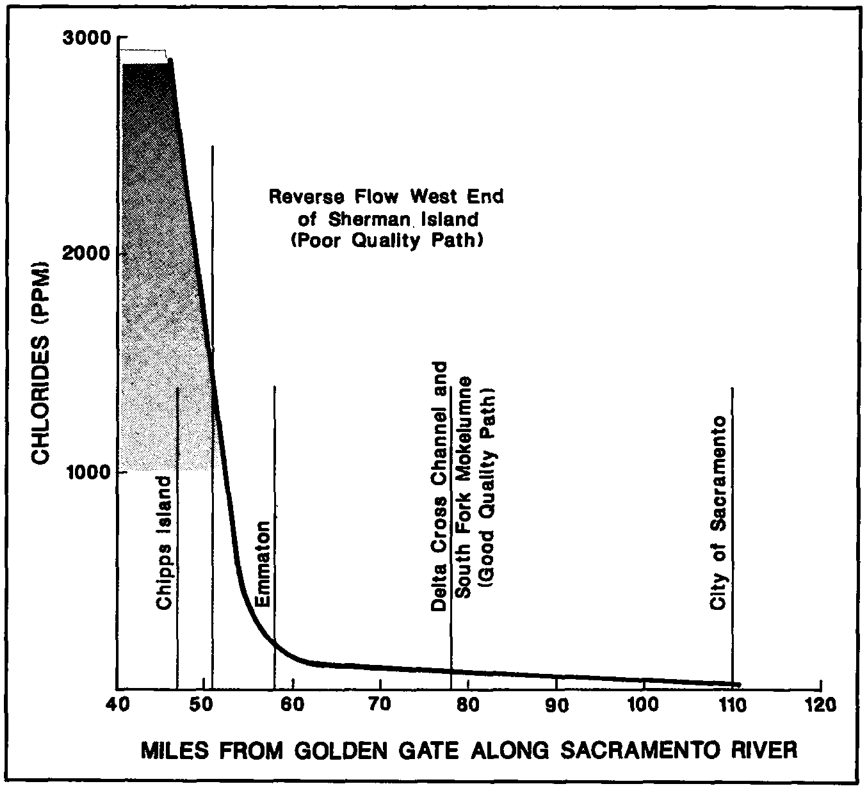
Levee improvements consist of modifications in existing levees to improve their structural integrity and/or increase their ability to handle flood flows. Improvements can consist of one or more of the following:

- Armoring, usually with rock, the water side of the levee;
- Increasing the height of the levee;
- Improving the structural stability of the levee by adding embankment material to the land side of the levee;
- Placing geotextile fabrics;
- Placing slurry walls; and
- Replacing brush and trees with herbaceous cover.

Delta Cross Channel Gate Improvements

The Delta Cross Channel, completed in 1951, has two 60–foot gates at the Sacramento River to augment the natural transfer of water southerly from the Sacramento River near Walnut Grove into the channels of the Sacramento–San Joaquin Delta (Figure 2–8). Floodwaters in the Sacramento River overtopped the closed gates during the storms in 1986, adding slightly to the flooding in the Mokelumne River system. Raising or modifying the Cross Channel gates would prevent flood waters from the Sacramento River from reaching the Mokelumne River system.

Adding more gates to the existing Cross Channel gate structure can significantly increase diversions into the central Delta. Engineering studies indicate that additional gates greatly enhance the effectiveness of channel enlargement in the Mokelumne River channels (Appendix H, Figure H–9).



At the City of Sacramento, 110 miles from the Golden Gate, chloride concentrations (a measure of ocean salinity) are low, and they remain so past the Delta Cross-Channel and South Fork Mokelumne River. Water from these sources is low in ocean salts. Downstream of Emmaton, chloride levels begin increasing at a faster rate.

Figure 2-7. Salinity Gradient Showing Increasing Chlorides with Reverse Flow Conditions

Partial Tide Gate Structures

A possible second phase of the NDP would include partial tide gate structures, strategically located in the Sacramento River and adjoining sloughs. They would raise water levels slightly during low-flow conditions so that more water would flow south through the channels upstream from the structures. This would diminish the amount of water following the undesirable reverse flow path around Sherman Island in the west Delta. These structures would be open during flood conditions and would be designed not to interfere with floodflows. The structures may have permanent openings in the center to minimize impacts on navigation and fish, and they would be operated to comply with SWRCB protective standards. Gates would be opened to let the incoming tide pass and would be closed to restrict the ebb, or declining tide.

The Tidal Cycle

The river systems of the Sacramento-San Joaquin Delta are open to the Pacific Ocean via the Golden Gate and are influenced by tides—two high tides and two low tides each day.

Each high-water stage raises water elevations and produces a flood tide that flows landward through Delta channels. As the tidal cycle continues, it reverses to a low water stage and produces an ebb tide that flows to the ocean and lowers water levels.

This regular cycle of changing flow directions and water elevations can be used to create desired hydraulic conditions by use of tide gates. These structures can be designed and operated to open and close on different phases of the tide, using natural forces to improve water levels and circulation.

Connecting Channels

A possible later phase would be connecting channels to further improve efficiency of water transfer through the Delta. The new channels would be dug and levees built to protect the surrounding land from a 100-year flood. A new connecting channel would allow more water to be conserved in reservoirs to increase water supply reliability. The necessity of connecting channels would be determined after earlier phases are constructed and operated.

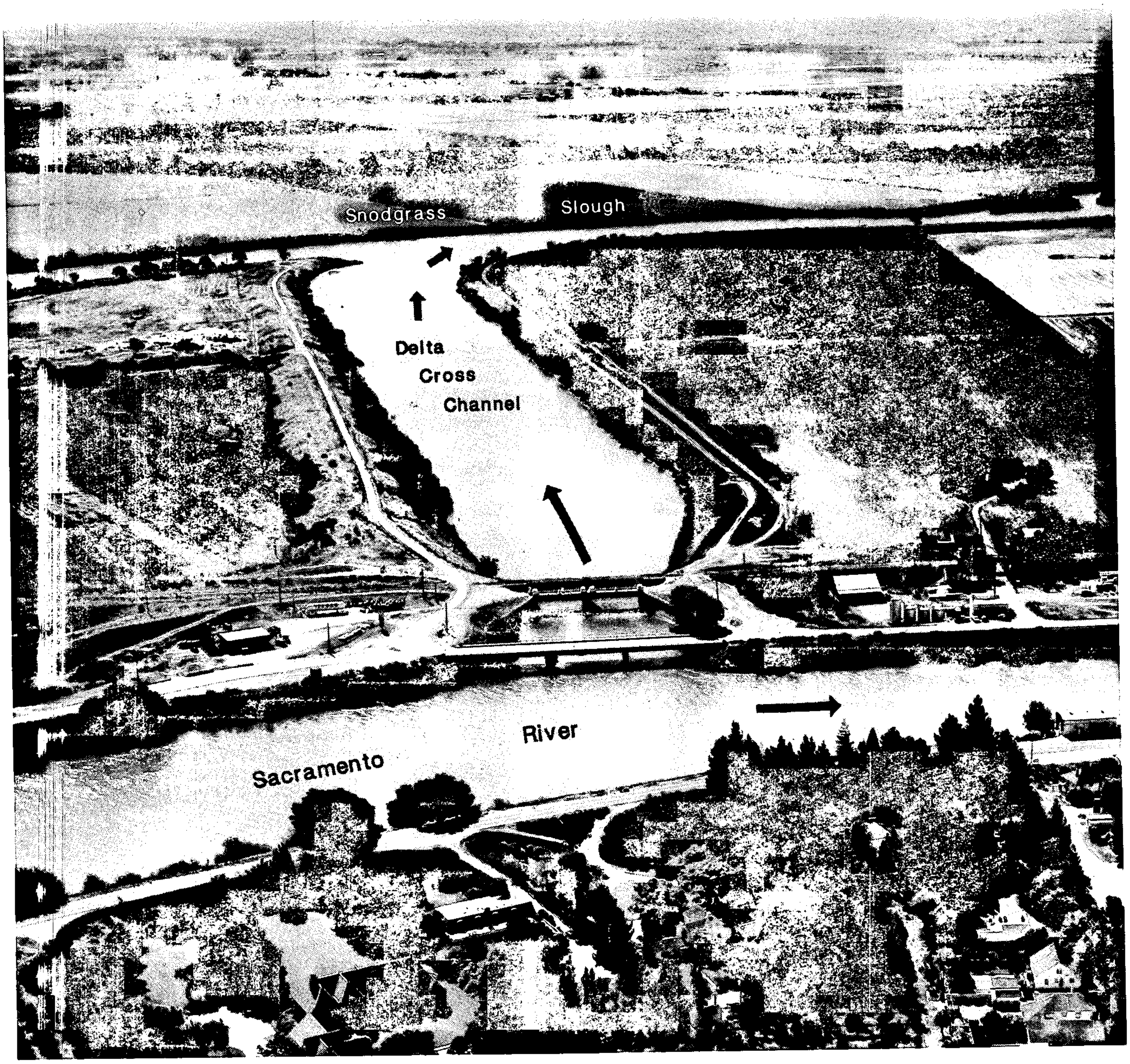


Figure 2-8. Delta Cross Channel

Chapter 3. DESCRIPTION AND COMPARISON OF ALTERNATIVES

The narrowing of alternatives for the North Delta Water Management Program (NDP) used a broad range of information that is important to water resources planning. The selection process considered previous studies, activities implemented during droughts, legislative activities, statewide referendums, comprehensive water conservation and reclamation activities. Previous studies evaluated alternatives on the basis of such factors as flood control needs, economics, energy, water supply, fisheries, wildlife, recreation, water quality, technological, legal, and institutional constraints, and political issues. A summary of previous studies and the narrowing of alternatives is provided in Appendix M. Appendix M also contains detailed criteria and assumptions on which the alternatives were compared.

In general, previous studies showed that an isolated facility would provide favorable reliability, fishery protection, and improved water quality when compared to other alternatives such as a physical barrier or a through–Delta facility. Recent updates of previous studies showed this same trend. However, the June 1982 voter rejection by State referendum indicated that an isolated facility was unacceptable to the public.

The previous studies also showed that a through–Delta system compatible with the objectives of the NDP would provide significant advantages over existing conditions. Extensive programs since 1975 to implement water conservation and reclamation will reduce projected growth in statewide demands by about 1.3 MAF by 2010. However, DWR Bulletin 160–87, *California Water: Looking to the Future*, November 1987, as well as this EIR, shows that water development would still be required to meet future statewide needs and alleviate current Delta problems. Recent population increases and water supply reductions have exacerbated the growing water supply shortage (see sidebar, page 30).

In addition, severe flooding occurred in 1986 in the north Delta study area. The need to protect against this type of flooding has been carefully considered in the alternative selection process. DWR recently prepared *Plan Of Action for Flood Control for the Towns of Thornton and Walnut Grove*, February 1989, in response to the Delta Flood Protection Act of 1988. In addition, the Corps, Sacramento County, and consultants have prepared numerous reports on various aspects of the flooding problems in the north Delta study area. These reports provide planning and engineering information used to define NDP objectives and alternatives.

The final decision on implementation of a NDP will involve implementation of an Article VII fish and wildlife agreement, which will define how the NDP contributes to mitigation for the Delta estuary and other specific mitigation requirements. The Article VII agreement will also specify the roles of the Department of Fish and Game (DFG) and Reclamation, as discussed in Chapter 5. The impact analysis of the NDP alternatives was designed to consider the contribution of each facility and the impact of combinations of facilities.

North Delta Water Management Program Alternatives

Two categories of alternatives were evaluated:

- North Delta Water Management Program (NDP) alternatives, and
- water supply augmentation and demand–reduction alternatives in project service areas.

Ten NDP alternatives and a no–action alternative were evaluated on the basis of overall operation of the State Water Project (SWP) and Central Valley Project (CVP), in compliance with operational considerations discussed later in this chapter. Also, 11 water supply and demand–reduction alternatives were incorporated into the economic analysis discussed later in this chapter. Environmental impacts are discussed in detail in Chapter 5 on the basis of comprehensive water supply, power, Delta water quality, and Delta hydrodynamic studies, assuming 3.8 MAF level of SWP demand. Potential cumulative impacts of related water resources projects are discussed in Chapter 6.

The impact of north Delta facilities improvements on the SWP, the CVP, water quality, Delta outflow, Delta fisheries,and other uses depends to some extent upon other Delta improvements, particularly south Delta improvements which may be implemented as a result of the South Delta Water Management Program (SDWMP). The environmental impact analysis and alternative selection process for that program is proceeding concurrently with this NDP. Accordingly, where cumulative or interactive impacts of the proposed north and south Delta improvements are critical, proposed north Delta alternative impacts were analyzed both with and without south Delta facilities in place.

The no-action alternative represents SWP operations according to existing Corps constraints and without improvements to conveyance capacity in north Delta channels for water supply or flood control.

The preferred alternative is to:

1) Enlarge the main stem and North Fork Mokelumne River with setback levees,
2) Dredge the South Fork Mokelumne River
3) Enlarge the Delta Cross Channel gates
4) Acquire the necessary state and federal permits, and
5) Test mitigation river collector wells and fish screens.

Each NDP alternative evaluated is a combination of various project components. The components include enlarging the Delta Cross Channel gates, dredging river channels, constructing setback levees, and constructing island floodways. Each of the alternatives analyzed would, to varying degrees, meet the objectives of the NDP. The alternatives were formulated to guarantee evaluation of all the different project components and to show the widest range of impacts. This is to ensure that, if a decision is made for a combination of facilities not discussed in this chapter, the impacts will be lower and the benefits greater than those described in Chapter 5.

The following NDP alternatives were evaluated:

1. No Action
2A. Dredge the South Fork Mokelumne River
2B. Dredge the South Fork Mokelumne River and Enlarge the Delta Cross Channel gates
3A. Dredge the South Fork and North Fork Mokelumne River
3B. Dredge the South Fork and North Fork Mokelumne River and Enlarge the Delta Cross Channel gates
4A. Enlarge the South Fork Mokelumne River and Dredge the North Fork Mokelumne River
4B. Enlarge the South Fork Mokelumne River and Dredge the North Fork Mokelumne River and Enlarge the Delta Cross Channel gates
5A. Enlarge the North Fork and main stem Mokelumne River and Dredge the South Fork Mokelumne River
5B. Enlarge the North Fork and main stem Mokelumne River and Dredge the South Fork Mokelumne River and Enlarge the Delta Cross Channel gates
6A. Create an island floodway
6B. Create an Island Floodway and Enlarge the Delta Cross Channel gates

Figures 3-1 and 3-2 show all eleven NDP alternatives.

Methods of Analysis

The alternatives were analyzed to determine their impacts upon:

- Flood flows, stages, and velocities,
- Normal and dry period flows, stages, and velocities;
- Water quality, particularly with respect to salinity distribution and THM formation potential;
- Fisheries, as a result of changes in water quality, redistribution of flows, changes in operation of the Delta Cross Channel, and operation of mitigation river collector wells;
- Delta outflow, Suisun Marsh, and the San Francisco Bay estuary;
- SWP operations, including yield, energy requirements, and costs;
- Wildlife habitat; and
- Recreational opportunities and navigation.

In addition, material quantities and construction costs were computed for each alternative to determine construction impacts and relative cost effectiveness.

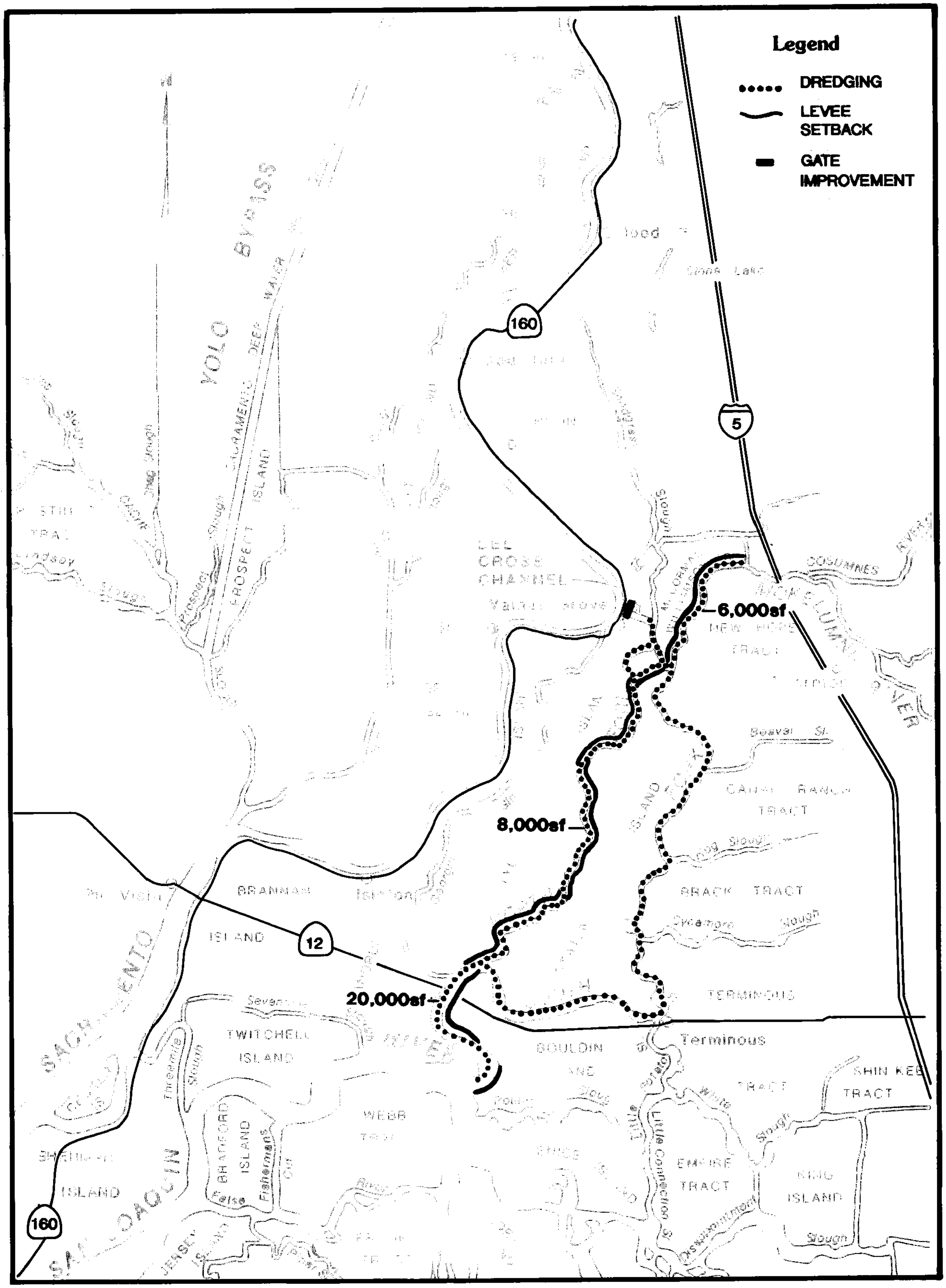
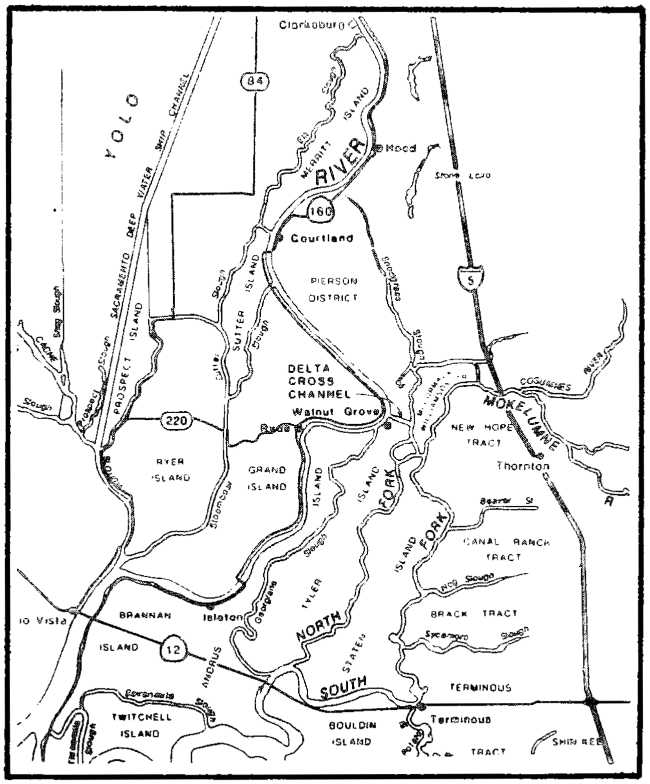
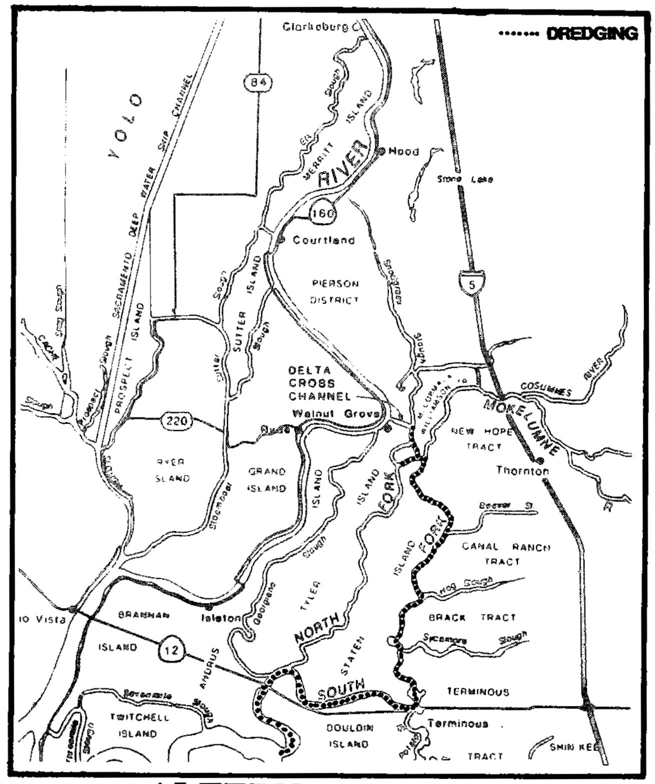


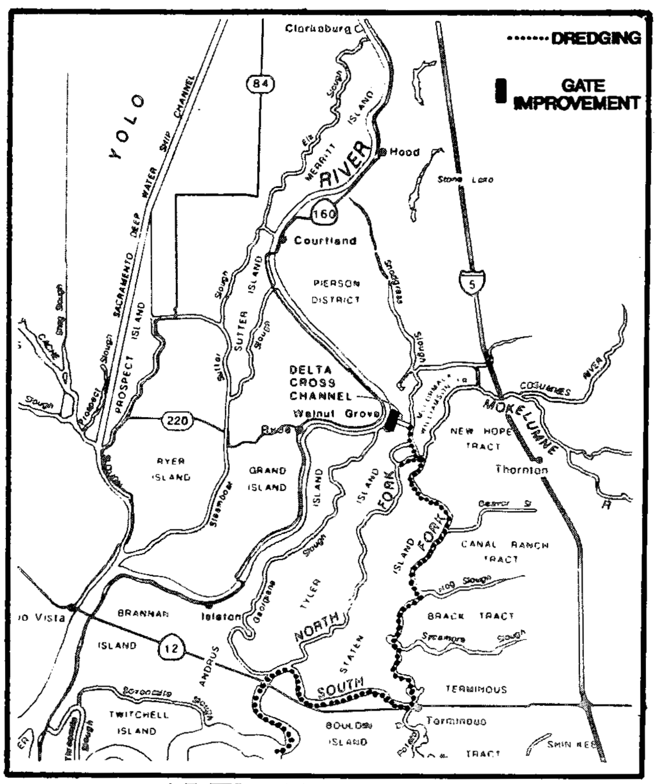
Figure 3–1. Preferred Alternative (5B)



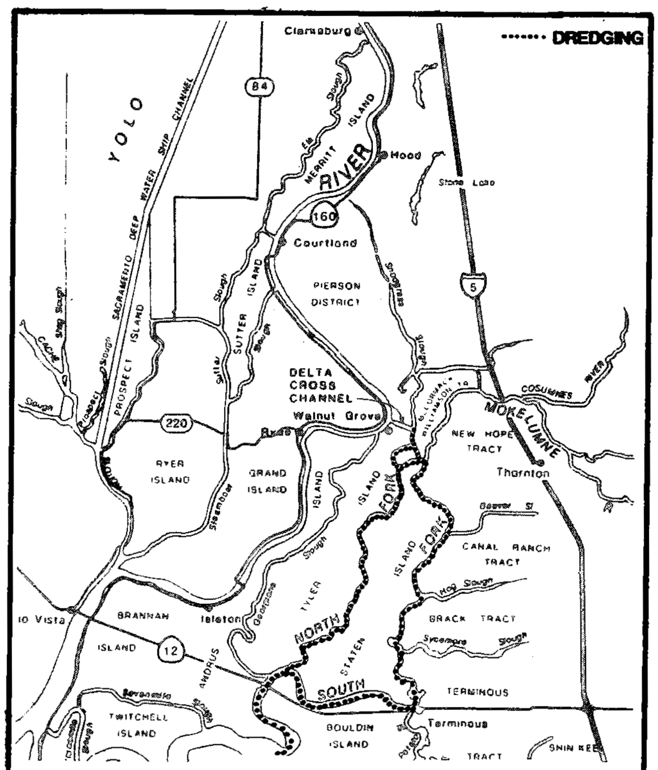
NO ACTION



ALTERNATIVE 2A

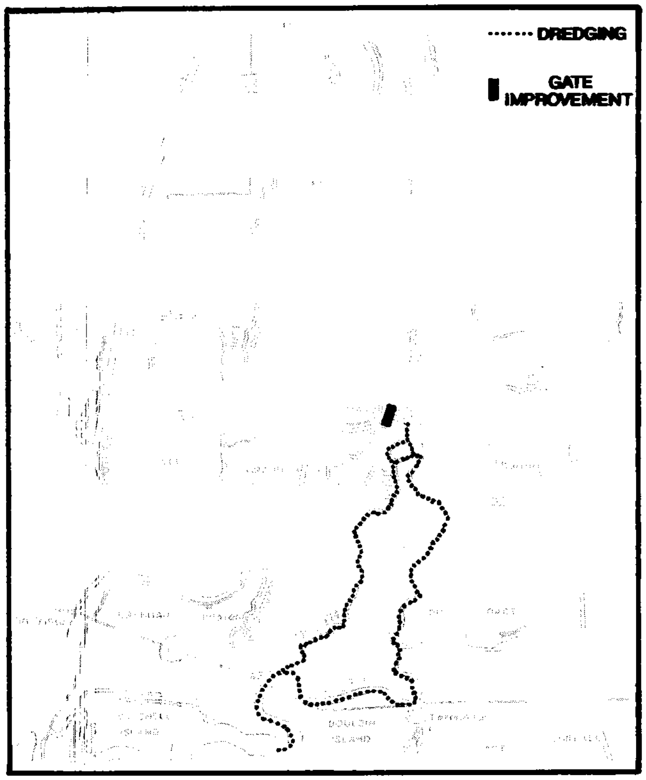


ALTERNATIVE 2B

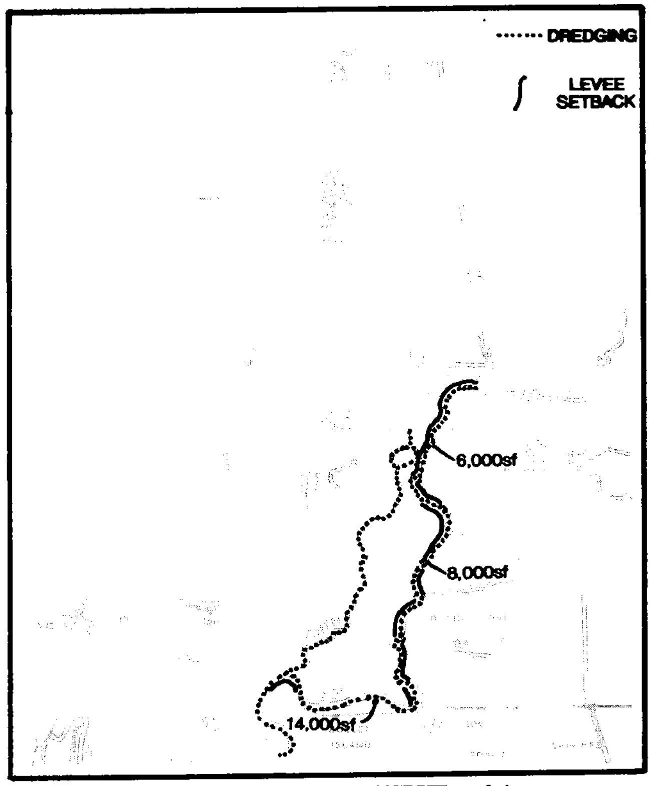


ALTERNATIVE 3A

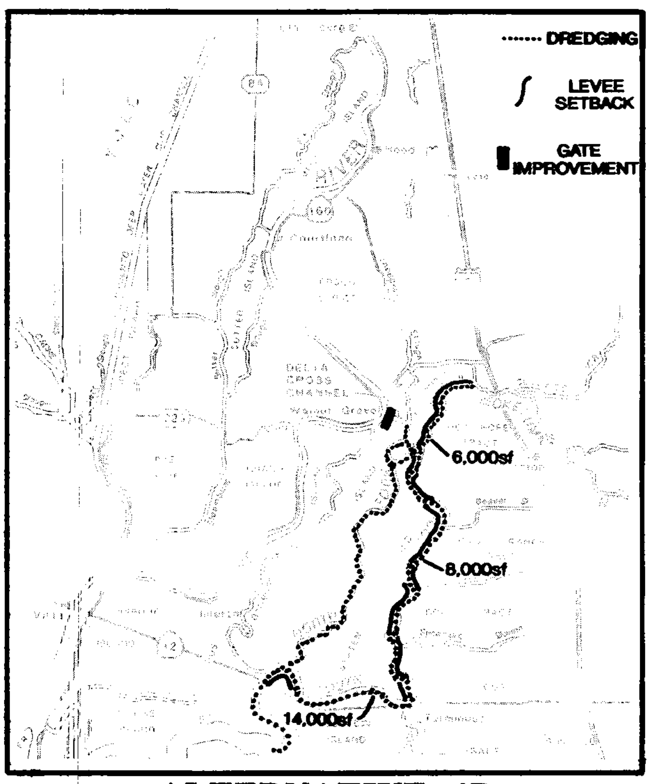
Figure 3–2, Sheet 1. Other Alternatives



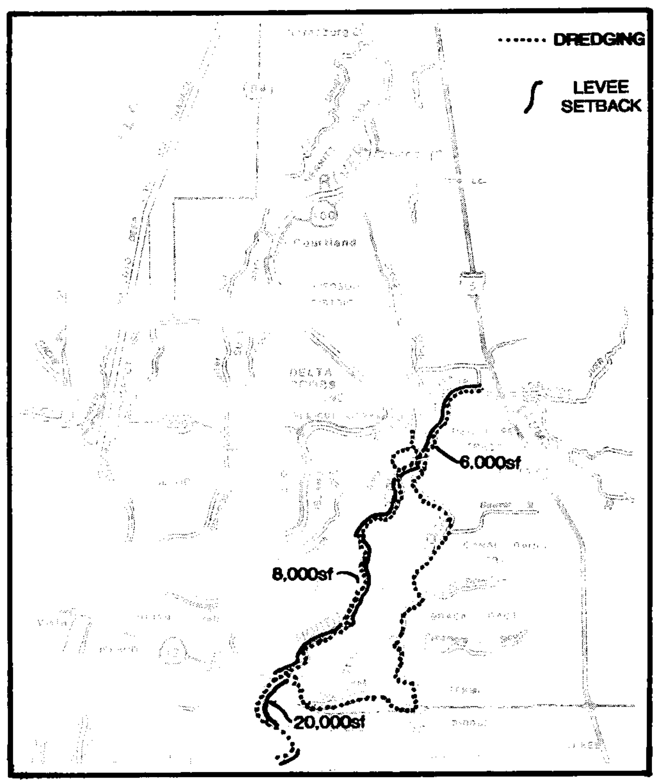
ALTERNATIVE 3B



ALTERNATIVE 4A

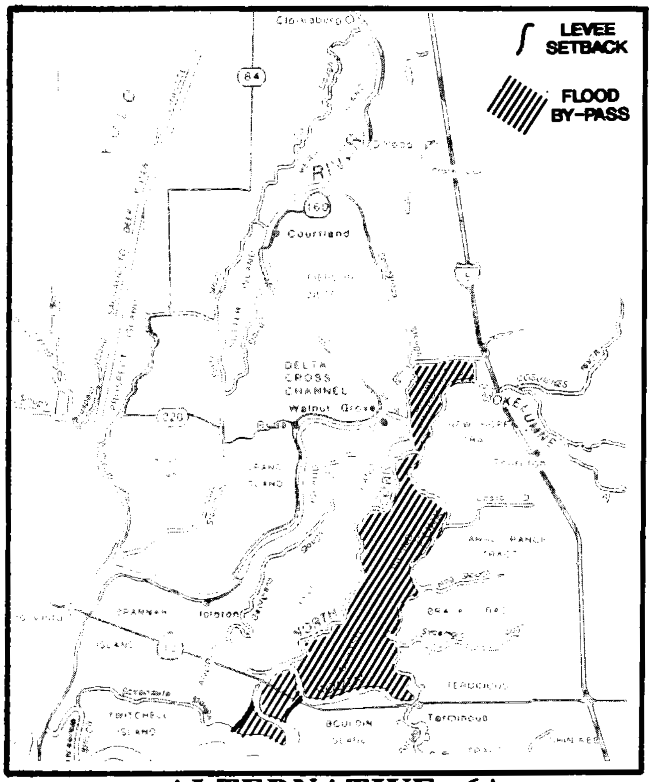


ALTERNATIVE 4B

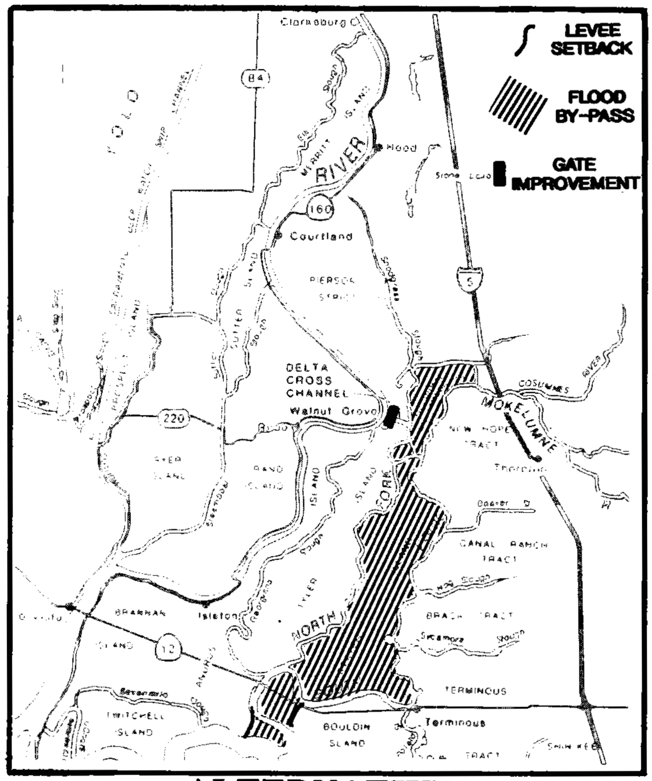


ALTERNATIVE 5A

Figure 3–2, Sheet 2. Other Alternatives



ALTERNATIVE 6A



ALTERNATIVE 6B

Figure 3–2, Sheet 3. Other Alternatives

Impacts upon flood flows, stages, and velocities were analyzed using a Dynamic Wave Operational Model (DWOPER) with a network option. This model, developed by Dr. D. Fread of the National Weather Service Office of Hydrology, was selected because it is capable of simulating the extremely complex flood hydrology of the north Delta study area. It effectively models flood wave transients, channel flows, water storage in overflow areas, levee failures and island flooding, tidal effects, impacts of hydraulic structures such as the existing and proposed Lambert Road structure, and the distribution of flood flows through a complex network of channels. About 118 cross sections were compiled from a number of sources to describe the channel geometry of the study area. Eye witness accounts from the 1986 flood, field evaluations, photographs, and previous studies were analyzed and used to refine the model parameters.

The inflows to the north Delta can not be measured directly, because as they approach the area they spread out over the land, moving overland and in a complex network of poorly defined channels and overflow areas. To estimate the timing and magnitude of flows at the study area boundary, a combination of flow measurement, flood routing, and local rainfall runoff analysis is required. Flood routing and local rainfall–runoff analysis was done using the HEC–1 model (Appendix C). The February 1986 flood was used for model verification, and the synthetic 100–year flood was used in the alternative analysis process. Summary statistics are shown in Table 3–1.

A wide range of alternatives was analyzed for impacts on Delta flows, velocities and stages during normal and low flow periods using the DWR/RMA hydrodynamic model. About 40 alternatives were screened and analyzed. The screening process covered a range of typical spring and summer hydraulic conditions, with a range of SWP export levels and Sacramento River flows (Appendix C). The model runs were used to evaluate the relative impacts of dredging, levee setbacks, and Delta Cross Channel enlargement on reverse flow, to optimize the proposed Del-

Table 3-1. Flood Statistics Summary

Stream	February 1986		100-Year	
	Peak flow (cfs)	7-Day Vol. (ac ft)	Peak Flow (cfs)	7-Day Volume (ac ft)
Morrison Creek Stream Group	13,768	17	9,023	11
Cosumnes River	51,653	314,509	70,606	323,691
Mokelumne River & Dry Creek	32,545	178,604	28,222	208,678

ta Cross Channel enlargement, and to select preferred channel segments for enlargement.

These runs were also used to estimate the impact of channel enlargement upon the Transfer Coefficient, which defines the proportion of Sacramento River flow entering Georgiana Slough and the Delta Cross Channel:

$$\text{Transfer Coeff.} = \frac{\text{Georgiana Slough + Delta Cross Channel Q}}{\text{Sacramento River Q}}$$

It was assumed the Delta outflow–salinity relationships described by the Export–Salinity equation (see *Supplemental Documentation to Appendix A of the DWR Memorandum Report, 'Operations Criteria Applied in DWR Planning Simulation Model,'* February 1986) were not changed, except that the transfer coefficient associated with each alternative could be substituted for the transfer coefficient associated with the base case. With the new transfer coefficients, a set of carriage water curves was derived for each alternative selected for detailed environmental impact analysis

Using the alternative carriage water curves, the State Water Project simulation program, DWRSIM, was used to simulate operations with a range of north Delta alternatives. These simulations provided monthly simulated data for the 1922–1978 historic data period. Changes in carriage water, net Delta outflow, and SWP pumping were analyzed to determine relative impacts upon fisheries resources in the Delta and the San Francisco Bay estuary. Changes in SWP pumping, wheeling of CVP water, and SWP deliveries were analyzed to determine impacts on project yield, energy requirements, and economics. Changes in reservoir storage elevations were analyzed to determine reservoir recreational impacts.

Output files generated by DWRSIM tabulate the major inflows and outflows to the Delta over the 57 year historic data period for each alternative analyzed. This data in turn provided the boundary conditions for operation of the DWRDSM, which simulates channel hydraulics and salinities. The DWRDSM was used to determine channel flows and salinities in key Delta channels for wet, above normal, below normal, dry, and critical years. This information was used to evaluate fisheries impacts and benefits.

During the alternative analysis process certain alternatives were dropped from further consideration and remaining alternatives were refined. In general it was found that reverse flow in the west Delta, as well as other channel flows in the study area varied predictably with north Delta channel conveyance capacity. It was thus possible to estimate impacts of refined alternatives on specific channel flows and salinities by interpolation from predictions based upon the original alternative set.

Much of the analysis of NDP alternatives was based upon considerations and assumptions about the future conditions in which the project would operate. These considerations and assumptions fall into three major classes: Operational considerations relate to future SWP demands, other SWP projects, legal and institutional controls, and factors affecting how the project is operated. Flood control considerations include the study area's flood hydrology, channel characteristics, levees and flood control structures, and legal and institutional constraints. Design considerations include assumptions about soils and foundation characteristics, results of field investigations, and legal and institutional constraints. These considerations are discussed in more detail below.

Operational Considerations

Operational considerations and assumptions include the following:

- It is assumed that WRCB Decision 1485 protective water quality, flow, and export standards, as well as criteria for Delta Cross Channel operation, are in effect.
- It is assumed that the Coordinated Operation Agreement defining the federal commitment to Delta protective standards, and a State/federal sharing formula

for water releases, is in effect. The agreement calls for renegotiation of the sharing formula for water releases whenever either the CVP or SWP adds new facilities (Article 6 and 14a), and requires that the agency which constructs new facilities realizes the additional yield attributable to them (Article 16).

- It is assumed that pumping and generation facilities are operated to maximize the use of off-peak power and generation of on-peak power to best utilize available power resources and minimize costs.
- It is assumed that the four additional pumps now under construction at the H.O. Banks Pumping Plant will be installed by the end of 1991. The Department agreed to operation of the pumping plant with the four additional units under the operational limits established by DWR and published in the Corps' Public Notice 5820A, Amended. This operation is discussed in the 1986 report, *Additional Pumping Units–Harvey O. Banks Delta Pumping Plant E.IR* It is assumed that SWP demand is 3.8 MAF. This corresponds to deliveries of 3.7 MAF and 70 TAF of transmission and evapotranspiration losses and recreational allocations.
- It is assumed that the SWP will be operated to minimize reverse flow and its negative impacts.

A detailed tabulation of assumptions incorporated into SWP operational studies under the various north Delta alternatives is provided in Appendix C.

Flood Control Considerations

Operational considerations and assumptions include the following:

- As described in detail in Chapter 2, the north Delta study area receives drainage from about 2,000 square miles of watershed, including the Morrison Stream Group (180 sq. mi.), the Cosumnes River (870 sq. mi.), Dry Creek (330 sq. mi.), and the Mokelumne River (670 sq. mi.).
- There are no significant flood control reservoirs on the Morrison Creek, Cosumnes River, or Dry Creek watersheds. The Mokelumne River has 11 reservoirs with capacities exceeding 1,000 AF. Camanche Reservoir is the most important, with a total storage capacity of 431,000 AF and a maximum flood control reservation of 200,000 AF. During the 1986 flood, releases from Camanche were limited to about 5,000 cfs, attributable to Camanche and upstream reservoirs. It is estimated that without these reservoirs, peak flow at the current location of Camanche Reservoir would have been about 44,000 cfs. The Corps is currently conducting a reconnaissance-level study of potential flood control reservoir sites on the Cosumnes and Mokelumne rivers. The study is scheduled for completion in December 1990.
- There is no flood bypass system for the flood flows in the north Delta study area. However, the area east of Franklin Road where the Cosumnes River, Dry Creek, and Mokelumne River channels converge has historically served as a flood detention area. The north and south Stone Lakes area north of Lambert Road provides about 74,000 AF of storage when the elevation at Lambert Road reaches 14 feet. Historically, water has spread out over these areas due to very limited channel capacity in the North and South Forks of the Mokelumne River downstream.
- Development upstream and channelization, particularly in the Morrison Creek watershed east of I-5, is intensifying inflows by causing reduced infiltration and more rapid runoff.
- Except for levees lining the Delta Cross Channel, levees affected by runoff from Morrison Creek, the Cosumnes River, Dry Creek, and the Mokelumne River watersheds are all non-project levees. They are maintained by local reclamation districts to varying and generally less stringent standards than project levees.
- Reclamation Districts in the north Delta study area, as well as the rest of the Delta, are working to meet FEMA Hazard Mitigation Plan levee standards (Figure 3-3). The deadline for compliance with FEMA HMP standards is September 1991. Reclamation Districts not in compliance with these standards may no longer be eligible for federal disaster assistance in future floods.
- Lambert Road, which runs east-west about 9 miles south of Freeport, caps a levee which generally prevents floodwaters from the Cosumnes River, Dry Creek, and the Mokelumne River from flowing north into the Stone Lakes basin. The road generally lies at

Figure 3–3. HMP Levee Standards

or above 18 feet above mean sea level, above the currently established National Flood Insurance Program 100 year flood elevation of 15 feet. Lambert Road crosses Snodgrass Slough about 1.7 miles west of I-5, on an old, structurally deficient bridge (now closed, due to safety concerns). Seven culverts, four feet in diameter and fitted with flap gates, and ten four foot by ten foot wooden flapgates allow the Stone Lakes Basin to drain into Snodgrass Slough, while preventing backflow from the south. The bridge deck, and the approach road on either end of the bridge, are at an elevation of about 11 feet above mean sea level. Leakage through the deteriorating flap gates and overflow over this low lying portion of Lambert Road allow flow from the south during major flood events. During the February 1986 flood about 13,000 AF of water flowed north over Lambert Road, contributing to a peak flood elevation of about 14.1 feet at the Lambert Road bridge.

Design Considerations

In the alternative formulation process some basic assumptions were made regarding design considerations:

- It was assumed that channel dredging would be limited to a depth of 20 feet below sea level in most areas for several reasons: First, channel sediment can help support levee embankments and excessive excavation could impact levee stability. Second, a variety of existing dredging equipment can readily reach the 20 foot depth. Third, with excessive excavation there is an increased risk of exposing layers of high hydraulic conductivity, with potential seepage impacts on adjacent lands. During the final project design phase dredging depth can be reassessed based upon detailed geotechnical data and the selection of dredging technique.
- It was also assumed that dredged material would be used to reinforce the existing levee embankments, to construct the proposed levee setbacks, or to construct waterside berms. If clamshell dredges are used, materials can be placed on the landward levee slope and toe, allowed to be drained, and then compacted. If hydraulic dredging is employed, significant land areas must be set aside for sediment basins, and the conveyance water must be allowed to clarify and return to the channel. Dewatering would take an extended period of time.
- For setback levee construction, it was assumed that poor, compressible organic peat and clay materials would be encountered in the foundation. Levee construction on such foundations would require mild levee slopes and construction in stages to prevent foundation failure and to facilitate gradual and more uniform settlement. Construction fabrics would be used underneath the levee embankment fill to maintain the integrity of the levee and to reduce the possibility of differential settlement.
- It was assumed that water side levee slopes would be protected with riprap from the levee crown to the base of the levee to guard against erosion during flood flows.
- Levees to be replaced by setback levees would be left in place as channel islands to provide channel separation, high quality riparian habitat, and destination points for recreational activities. It was assumed that these levees would also require riprap to prevent excessive erosion from flood flows and wave action.
- Similarly, for the island floodway options, it was assumed that existing island levees would have to be riprapped on the interior slopes.

Comparison Of Physical and Operational Features

The various alternatives involve channel improvements by either dredging and/or constructing parallel channels to increase flow capacities. For the case of alternatives where the South Fork Mokelumne River to the San Joaquin River is to be modified, work could be done via Little Potato and Little Connection Sloughs or via the South Fork Mokelumne River past the confluence of the north and south forks. Modeling has shown that encouraging flow through the central Delta has the largest reverse flow reduction benefit. However, alternatives that encourage flow solely down the Mokelumne River channels could be less disorienting to migratory fish species. Improvements to the Delta Cross Channel will be limited to increasing the number of bays, allowing more water diversions from the Sacramento River into the Mokelumne River system for eventual transfer to the central Delta.

The Delta Cross Channel gates operate according to the schedule outlined in Decision 1485 to regulate flows to protect migratory fish and maintain water quality in the Delta. For the purpose of this study , the gate operation remained the same for all of the alternatives. The alternatives are described in the following paragraphs. A summary of physical features, quantities, and costs is shown in Table 3-2.

Table 3-2 Summary of Estimated Major Material Quantities Needed for Construction of North Delta Program Facilities

Item	Unit	Project Alternatives									
		2A	2B	3A	3B	4A	4B	5A	5B	6A	6B
Excavate Existing Channel	CY	3,527,000	3,527,000	6,548,000	6,548,000	15,569,000	15,569,000	10,831,000	10,831,000	2,937,000	2,937,000
Reinforce Existing Levee	CY	219,000	219,000	295,000	295,000	1,280,000	1,280,000	806,000	806,000	---	---
Excavate New Channel	CY	---	786,000	---	786,000	9,950,000	10,736,000	7,960,000	8,746,000	---	786,000
Berm Embankment using Channel Excavation	CY	---	---	---	---	2,980,000	2,980,000	1,811,000	1,811,000	---	---
Levee Embankment using Channel Excavation	CY	---	123,000	---	123,000	2,808,000	2,931,000	1,388,000	1,511,000	---	123,000
Levee Embankment using Imported Borrow	CY	---	17,000	---	17,000	9,762,000	9,779,000	5,507,000	5,524,000	2,592,000	2,609,000
Riprap	TON	126,000	189,000	243,000	306,000	1,654,000	1,717,000	1,423,000	1,486,000	1,944,000	2,007,000
Bedding (6" under riprap)	TON	36,000	50,000	70,000	84,000	550,000	564,000	463,000	477,000	550,000	564,000
Geotextile	SF	1,117,000	1,533,000	2,156,000	2,572,000	31,855,000	32,271,000	27,861,000	28,277,000	13,496,000	13,912,000
Concrete-Structural	CY	---	16,000	---	16,000	10,000	26,000	10,000	26,000	39,300	55,300
Reinforcing Steel	LB	---	3,288,000	---	3,288,000	2,392,000	5,680,000	2,392,000	5,680,000	8,549,000	11,837,000
Structural Steel	LB	---	720,000	---	720,000	---	720,000	---	720,000	---	720,000
Structural Excavation	CY	---	123,000	---	123,000	---	123,000	---	123,000	17,000	140,000
Land Acquisition	AC	---	15	---	15	1,229	1,244	1,041	1,056	12,700	12,715
Alternative Costs (in $1,000) (NOT INCLUDING MITIGATION COSTS)		**$29,000**	**$59,000**	**$53,000**	**$83,000**	**$368,000**	**$398,000**	**$260,000**	**$290,000**	**$250,000**	**$280,000**

[shaded] Preferred Alternative

Project Alternatives

All the project alternatives are described in the following paragraphs and shown on Figures 3-1 and 3-2.

1. No-Action

Under this alternative, no action would be taken. Channels would not be modified by dredging or enlargements, and the Delta Cross Channel and Cross Channel gates would not be enlarged to divert more water. Therefore, during high flow conditions, flooding potential would remain high due to flow constraints and inadequate flow capacity in the Mokelumne River system. As siltation continues, flooding potential can be expected to increase. During low flow conditions, limited diversion capacity of the Delta Cross Channel and flow constraints in the Mokelumne River system would force more water to flow down the Sacramento River and around Sherman Island producing the reverse flow effect in the western Delta.

2A. Dredge South Fork Mokelumne River

This involves dredging of the South Fork Mokelumne River from New Hope Landing to the San Joaquin River for a distance of 19.4 miles plus a short segment of Snodgrass slough from the Delta Cross Channel to New Hope Landing for a length of 1.9 miles totaling approximately 21.3 miles. The channels would be increased in cross sectional areas by dredging to a bottom elevation of 20 feet below mean sea level. Dredging would be done generally following the existing side slopes but not to exceed 2:1, while maintaining the existing riprap and the vegetation as much as possible. As a result, the bottom width of the improved channels would depend on the width and side slopes of the existing channels. Channels would not be dredged where the existing channel sections are greater than 8,000 sf. For this reason, only about 12.5 miles of the total of 21.3 miles would be dredged for this alternative.

Channel islands would not be disturbed in order to preserve their integrity as wildlife habitat areas. This alternative would increase channel flow capacity during both high and low flow periods. During high flow conditions, flood stages would be reduced as indicated by north Delta modeling, thereby decreasing the potential for island flooding. During low flow conditions, the increased downstream flow capacity would allow more water to flow through the Delta Cross Channel to the central delta. The increased flow through the north Delta would reduce reverse flow in the San Joaquin River and other channels in the central Delta which would improve water quality and reduce fishery impacts.

2B. Dredge South Fork Mokelumne River and Enlarge Delta Cross Channel Gate Structure

This alternative includes the same channel improvements as the previous alternative except that the Delta Cross Channel gate structure would be enlarged by adding three more gates to the existing two gates. This would increase the total flow area of the gate openings from 1,640 sf of the existing two gates to the desired 4,500 sf which would allow increased diversion from the Sacramento River. The existing Delta Cross Channel is large enough and would not require enlargement to pass the increased flow from the added gates. During high flow conditions, this increased gate size would not change the flood potential as compared to dredging alone because the Delta Cross Channel gates are closed when either the Delta outflow exceeds 12,000 cfs or when the Sacramento River flow at the I street bridge in Sacramento is over 30,000 cfs. During low flow conditions, diversions from the Sacramento River through the Delta Cross Channel would be significantly higher than dredging alone due to the larger gate size. This would transfer more water into the central Delta to reduce reverse flow.

3A. Dredge South Fork and North Fork Mokelumne River

This includes dredging of both the South Fork and the North Fork Mokelumne Rivers from New Hope Landing to the San Joaquin River plus dredging of the channels from the Delta Cross Channel to New Hope Landing. The total lengths of these channels would be 31.7 miles of which about 22.9 miles would be dredged. The remaining 8.8 miles have a channel capacity exceeding 8,000 sf and would not be dredged further. The maximum depth of dredging would be limited to about 20 feet below mean sea level as indicated earlier. The North Fork is not as choked with sediment as the South Fork, so there is only a modest increase in channel capacity when it is dredged. However, this dredging alternative provides the maximum increase in channel capacity which can be achieved dredging only. During high flow conditions, there would be further reduction in flood stage over that of alternative 2A, and during low flow conditions, the higher conveyance capacity of the dredged channels would allow more water to be diverted from the Sacramento River through the Delta Cross Channel into the central Delta to help reduce reverse flow in the lower San Joaquin River.

3B. Dredge South Fork and North Fork Mokelumne River and Enlarge Delta Cross Channel Gate Structure

This alternative is identical to Alternative 3A except that the Delta Cross Channel gate structure would be enlarged from 1,640 sf to 4,500 sf of opening. The increased gate size has no impact on flood stages; however, during low flow conditions, the increased gate size combined with the enlarged channels would increase the proportion of Sacramento River water diverted through the Delta Cross Channel and into the central Delta, resulting in a larger reverse flow reduction.

4A. Enlarge South Fork Mokelumne River and Dredge North Fork Mokelumne River

In this alternative, the Mokelumne River and the South Fork Mokelumne River would be enlarged with a combination of dredging the existing channel and excavating a new parallel channel from I- 5 to the San Joaquin River for a total length of 22.8 miles, whereas the North Fork Mokelumne River and other channels from the Delta Cross channel to New Hope Landing would be dredged for a length of 12.3 miles.

The deepest excavation for the old as well as the new channels would be about 20 feet below mean sea level. The combined cross section of the new and existing channel would be 6,000 sf from I-5 to New Hope Landing (3.4 miles), 8,000 sf from New Hope to Terminous (10.6 miles), 14,000 sf from Terminous to the confluence with the North Fork Mokelumne River (4.8 miles), and 20,000 sf from the North Fork–South Fork confluence to the San Joaquin River (4.0 miles).

The new parallel channel may alternate sides of the existing channel to bypass major structures and public utility facilities; and to take advantage of variations in soil properties and existing levee characteristics. With the enlargement of the South Fork Mokelumne River with setback levees, flood stages in the North Delta would be reduced significantly, and the reduction would be considerably greater than what could be achieved by dredging alone as for alternatives 2A, 2B, 3A, and 3B. During low flow conditions, the increased downstream channel size would allow greater diversions from the Sacramento River through the Delta Cross Channel into the central Delta than that would be possible by dredging the channels only. The new parallel channels would improve navigation and provide additional valuable habitat for Delta wildlife. The increased water surface area provided by the new parallel channels would also increase navigation and enhance recreational activities in the Delta. Provision has been made for a 50 feet wide berm with crest elevation slightly above the normal water surface elevation on each side of the new channels to support riparian vegetation and enhance fisheries and wildlife habitat.

For the new parallel channels and the setback levees, approximately 1,229 acres of land would have to be acquired from McCormack Williamson Tract, Dead Horse, Staten, and Bouldin islands of which 927 acres would be from Staten island. A new two-lane bridge would be required on Thornton–Walnut Grove road to span the enlarged channel. The total length of the setback levees and the new parallel channels is 22.8 miles. The setback levees would require about 13 million cubic yards of borrow materials of which 10 million cubic yards would be imported from outside the project area and the remaining 3 million cubic yards would be from dredging and channel excavation. This alternative is far more expensive than previous alternatives due to the costs associated with the construction of the new channel with a berm on each side, a new levee with riprap on water side slope, a new bridge, and land acquisition. Setback levee construction with imported embankment material would be the most expensive item.

4B. Enlarge South Fork Mokelumne River, Dredge North Fork Mokelumne River, and Enlarge Delta Cross Channel Gate Structure

This alternative is identical to alternative 4A except that the Delta Cross Channel gate structure would be enlarged with three additional gates increasing the net flow area from 1,600 sf of the existing two gates to a total of 4,500 sf of openings as described in connection with alternative 2B. This would allow more water to be diverted from the Sacramento River into the central Delta than would otherwise be possible only with enlargement of the South Fork Mokelumne River and dredging the North Fork Mokelumne River as in alternative 4A. The increased potential for Sacramento River diversion due to gate enlargement would further enhance reduction in reverse flow through the central Delta. However, the enlargement of the Delta Cross Channel gate structure would not change the flood stage reduction benefit identified in alternative 4A.

5A. Enlarge North Fork Mokelumne River and Dredge South Fork Mokelumne River

This alternative would include enlargement of the Mokelumne River and the North Fork Mokelumne River from I-5 to the San Joaquin River, and dredging of the South Fork Mokelumne River and other channels from the Delta Cross Channel to New Hope Landing. The enlargement would include dredging of the North Fork Mokelumne River and excavating parallel channels with setback levees for a length of 12.5 miles. As in other alternatives, the depth of dredging of the existing channel and excavation of new channel would be about 20 feet below mean sea level. The required combined cross section of the new and existing channel would be 6,000 sf from I-5 to New Hope Landing (3.4 miles), 8,000 sf from New Hope Landing to the confluence with the South Fork Mokelumne River (9.1 miles), and 20,000 sf from South Fork–North Fork confluence to the San Joaquin River (4.0 miles).

The total length of the setback levees and the new parallel channels is 16.5 miles. The setback levees would require approximately 7.0 million cubic yards of borrow materials of which 5.5 million cubic yards would be imported from outside the project area and the remaining 1.5 million cubic yards would be borrowed from dredging and channel excavation.

A 50 feet wide berm would be provided on each side of the new channel with crest elevation slightly above the normal water surface level to support riparian vegetation and enhance fisheries and wildlife habitat.

For the new parallel channel and the setback levee, approximately 1,041 acres of land would have to be acquired from McCormack Williamson Tract, Dead Horse, Staten, and Bouldin islands of which 690 acres would be from Staten island. A new two-lane bridge would be required on Thornton–Walnut Grove road to span the enlarged channel. Total length of the South Fork Mokelumne River and other channels from Delta Cross Channel to New Hope Landing is 18.6 miles of which 13.8 miles would be dredged, the balance 4.8 miles are large enough to require no further dredging.

The overall benefits and impacts accrued from this alternative in terms of reduction in flood stages, greater diversions from the Sacramento River, improvement in navigation, recreation, and wildlife habitat would be very similar to alternative 4A as described above. The cost of this alternative would be significantly less than that of alternative 4A because the length of setback levees and the new channels is considerably less than for alternative 4A.

5B. Enlarge North Fork Mokelumne River, Dredge South Fork Mokelumne River, and Enlarge Delta Cross Channel Gate Structure (Preferred Alternative)

This alternative is identical to alternative 5A except that the Delta Cross Channel gate structure would be enlarged with three additional gates increasing the net flow area from 1,600 sf of the existing two gates to a total of 4,500 sf of openings as described in connection with alternative 2B. This would allow more water to be diverted from the Sacramento River into the central Delta than would otherwise be possible only with enlargement of the North Fork Mokelumne River and dredging the South Fork Mokelumne River as in alternative 5A. Gate enlargement would further increase the flow beyond that achievable by the channel enlargement associated with alternative 5A. However, the enlargement of the Delta Cross Channel gate structure would not change the flood stage reduction benefit identified in alternative 5A.

6A. Create an Island Floodway

Under this alternative, McCormack–Williamson Tract, Dead Horse Island, and Staten Island, as well as parts of Bouldin Island and Brannan-Andrus Island, would be converted to a floodway. The levees parallel to the prevailing flood flows would be left in place and the interior levee slopes would be rip-rapped to prevent erosion due to wave wash and flow. The levees which lie transverse to the flood flows would be removed. New levees would be required on parts of Bouldin and Brannan-Andrus islands.

The interior of Staten island is about 15 feet below sea level at the southern end and about 5 feet below sea level at the upper end. Thus the island would be entirely inundated. The interior of Dead Horse Island is about 5 feet below sea level and would also be inundated. Except for the southwest end, most of McCormack–Williamson Tract is at, or slightly above, sea level and thus would not be inundated.

This alternative would also result in a large reduction in reverse flow, primarily because the interior of Staten Island would provide a large (although relatively shallow) addition in conveyance capacity during low flow periods.

This alternative would result in the loss of over 10,000 acres of highly productive farmland with its associated economic and wildlife habitat values. McCormack–Williamson Tract could continue in agricultural use or be managed for wildlife habitat as mitigation for project impacts. It is anticipated that agricultural operations would be significantly less attractive, due to frequent inundation, waterlogged soil, erosion damage, and deposition of flood debris.

Inundation of Dead Horse and Staten Island would result in low velocities during normal to low flow periods. It is anticipated that water temperatures would be significantly increased as the water spreads out and moves slowly across the island. The higher temperatures would adversely affect fishery resources, particularly salmon migrating through the north Delta.

There may also be significant water quality impacts in the west Delta, because inundation of Staten Island would significantly increase the tidal prism of the Delta. Likely impacts would be a reduction in daily tidal fluctuations in the north Delta study area, and increased salinity in the west Delta.

6B. Create an Island Floodway and Enlarge the Delta Cross Channel Gate Structure

This alternative is similar to 6A, except that the Delta Cross Channel gate structure would be enlarged to 4,500 sf. This would result in an additional reduction in reverse flow, resulting in the greatest reverse flow reduction of any alternative considered. Like 6A, it also provides the greatest flood stage reduction of all the configurations evaluated. Impacts upon agricultural land, water temperatures, water quality, and fisheries would be similar to Alternative 6A.

Mitigation River Test Wells

River collector wells can provide a potential mitigation measure for reducing the entrainment of migrating fish during critical periods. These wells would consist of horizontal collectors distributed directly under the Sacramento River bed, and a collection system for conveying the percolating water to the Mokelumne River system (Figure 3–4). Such a system may be relatively expensive to construct and operate and would provide limited capacity. However, it provides an option for reducing the entrain-

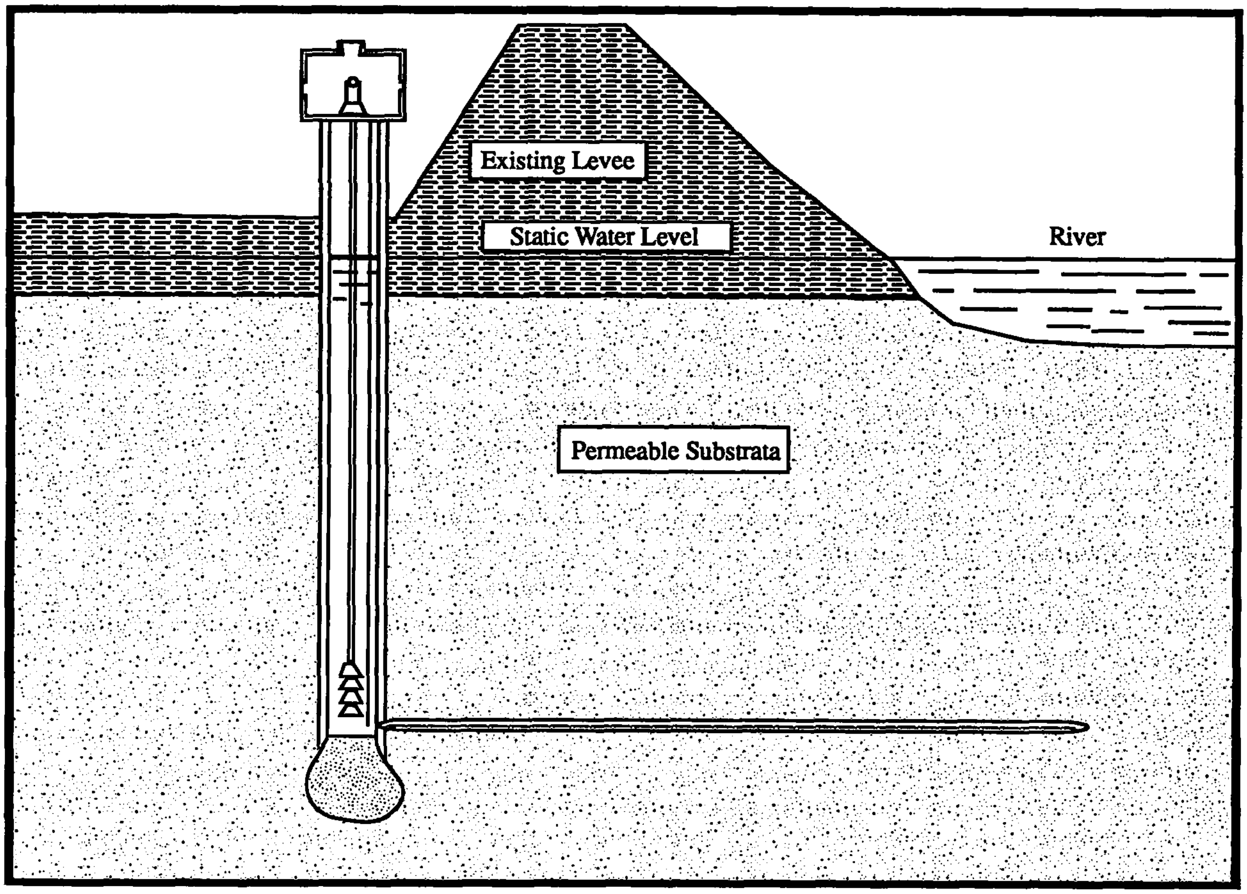


Figure 3–4. Preliminary River Collector Well Design

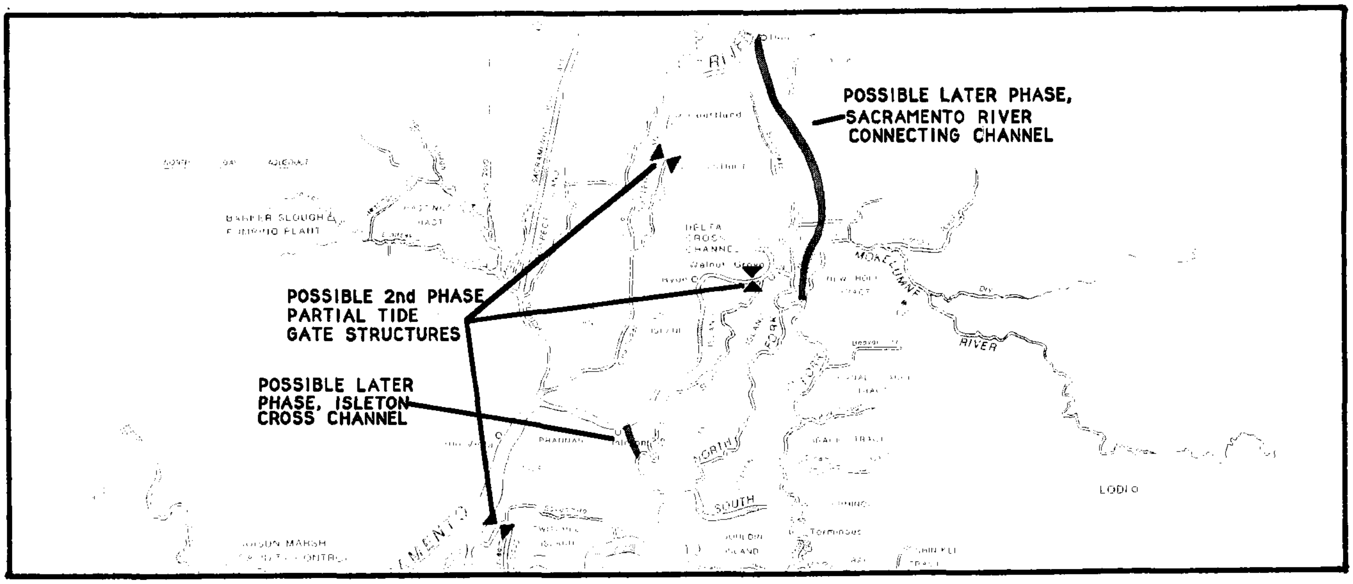


Figure 3-5. Possible Later Phases

ment of fish eggs, larvae, smolts, and adults in diversions from the Sacramento River. The wells can be tested on a small scale to determine effectiveness and then scaled up if they are determined to be effective. Another option would be to divert approximately 100 cfs from the Sacramento River to study fish screen design alternatives

Alternatives for Later Phases

In addition to these alternatives, other alternatives for reducing reverse flow have been considered and may be implemented after the Phase I of north Delta improvements, discussed in this report, have been constructed and evaluated. Phase II could include the installation of partial tide gate barriers in the Sacramento River and Steamboat Slough (Figure 3-5). Later phases could include an additional tide gate structure in Threemile Slough and the construction of additional connecting channels to the Sacramento River. The alternative components which could be implemented in Phase II and later phases are summarized below:

Tide Gate Structures

The proposed tide gate structures in the Sacramento River and Steamboat Slough would raise water levels slightly during low flow conditions so that more water would be forced through the Delta Cross Channel and Georgiana Slough into the Mokelumne River system, the desirable path for water transfer. This would diminish the amount of water following the undesirable reverse flow path around Sherman Island in the west Delta. The gates would take advantage of the daily tidal cycles, opening and closing at the appropriate tide phase to encourage flow of high quality water to the interior of the Delta. The gates would be opened to pass floodwaters unhindered, and may have openings for boat and fish passage.

Several structural alternatives for such partial tide gate structures have been evaluated with respect to impacts on summer flow stages, flood stages, fish migration, recreation, navigation, and aesthetics. Both friction loss and form loss structures were considered, but friction loss structures were judged to be impractical for a number of reasons, including size, safety, and cost. Eight form loss structures were evaluated, including conventional radial gate structures, inflatable dams, removable dumped rock weirs, wicket gate structures, and others.

The selection was narrowed to three structures: Conventional radial gates, with and without a permanent opening for boat and fish passage, a dumped rock weir, and wicket gates.

The Corps has constructed and is operating a wicket gate structure on the Ohio River, and is in the process of designing an improved, hydraulically operated structure. Design, construction, inspection and maintenance would be more challenging than for a conventional gated structure in which machinery and critical parts are accessible above the water surface. However, a wicket gate structure has major advantages in that the gates are hinged on a sill at the bottom of the river, and can be lowered to lie flat on the bottom to leave the river completely unobstructed for flood flows, fish migration, barge and recreational traffic, and aesthetic concerns. The wicket gates could also be operated individually to block part of the river completely and leave an opening for boat and fish passage, or partially raise all gates to reduce the channel cross sectional area without breaking the water surface. For these reasons, the wicket gate approach looks the most promising at the present time (Figure 3-6).

Detailed engineering and environmental analysis will be deferred until evaluation of Phase I facilities indicates that additional measures to reduce reverse flow are required.

New Connecting Channels for Through Delta Flow

A new connecting channel between the Sacramento River and the interior Delta could be constructed in the vicinity of Isleton or Hood. A new intake structure and channel in the vicinity of Isleton could connect the Sacramento River to Georgiana Slough. This channel would be relatively short (4,000 feet), but foundation conditions in this area are very poor, due to deep layers of peat.

A new intake structure and connecting channel from Hood to the Mokelumne River parallel to Snodgrass slough could greatly increase the flow of Sacramento River water into the interior Delta. This channel would be about 12 miles long, and would discharge into Lost Slough, the Mokelumne River, and Beaver Slough.

Detailed engineering and environmental analysis will be deferred until evaluation of Phase I facilities indicates that additional measures to reduce reverse flow are required.

Water Conservation And Demand Reduction Alternatives

California will meet its future water needs primarily through a wide variety of management actions designed to supplement, improve, and make better use of existing systems. These include reduction of demand through water conservation, water reclamation, and desalinization.

For the SWP, the present dependable supply is about 2.3 MAF. DWR Bulletin 160-87, *California Water: Looking to the Future*, November 1987, projected water requirements to be met by the SWP in year 2010 to be about 3.6 MAF, assuming: 1) 250 TAF of water conserved in the Imperial Valley becomes available to the South Coast Region; 2) waste water reuse increases of 200 TAF in SWP service areas; and 3) water conservation measures continuing through 2010. Under these assumptions, the existing SWP facilities would have a deficit in dependable supplies in 2010 of some 1.3 MAF in addition to ground water overdraft. This deficit prediction, however, has probably been underestimated for the following reasons:

- Population growth in the South Coastal Region has been much faster than was projected in Bulletin 160-87. To date, the population is about 0.5 million higher than was estimated for 1990.
- 1990 Department of Finance interim projections show that the California population in 2010 will exceed the projections made in DWR Bulletin 160-87 by 3 million.
- Los Angeles Department of Water and Power (LADWP) has been diverting up to 100 TAF per year from the Mono Lake Basin. The average diversion from 1970 through 1988 was 84 TAF per year. The recent Superior Court ruling, which mandated drastic cuts in the city's diversions, could reduce LADWP supplies by about 60 TAF per year.
- Some ground water supplies have been lost due to chemical pollution of ground water basins.

Major water management actions that could offset the predicted deficit consist of:

- water supply additions consisting of the SDWMP, NDP, LBG , and KWB;
- increased water conservation measures (beyond those incorporated into the Bulletin 160-87 projectiions); and
- other demand reduction measures.

Water Conservation

Following the statewide drought of 1976-77 and the subsequent formation of the Office of Water Conservation (OWC) in 1979, DWR began an aggressive water conservation program to achieve efficient use of California's limited water resources by promoting water conservation policies and practices that have the greatest public benefit and that are consistent with sound resource conservation principles. DWR, through the OWC, has administered several plans and programs that encourage efficient use of water, and has focused on cost-effective urban and agricultural conservation programs carried out in cooperation with local agencies throughout the State. Legislation has also been adopted to encourage and improve water conservation in the State. The two most recent significant pieces of legislation are 1) the Urban Water Management Planning Act of 1983 and 2) the Agricultural Water Management Planning Act of 1986. Both require the larger

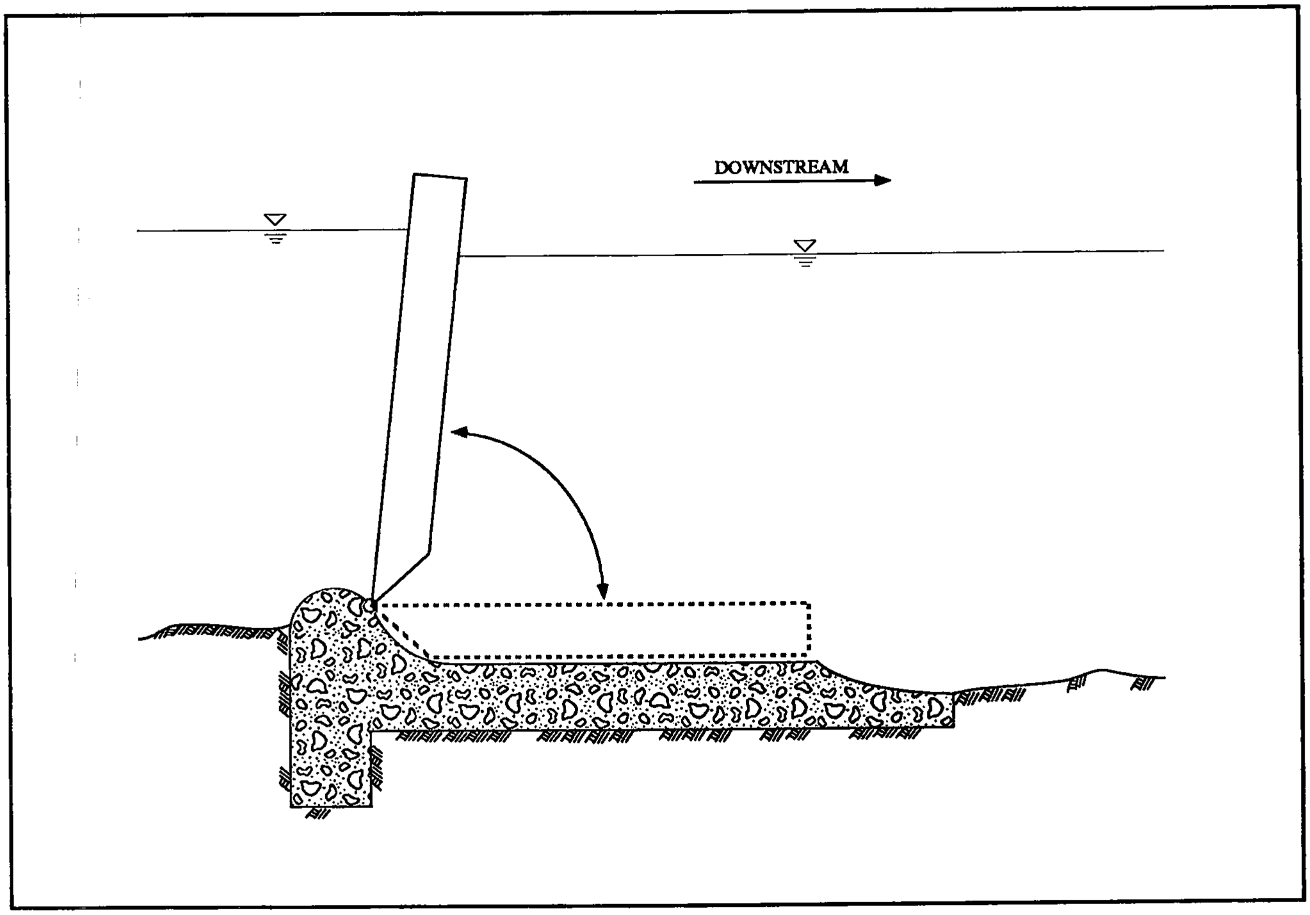


Figure 3–6. Preliminary Tide Gate Structure Design

water suppliers, under certain conditions, to prepare water management plans.

More than 300 urban water suppliers have prepared water management plans under the Urban Water Management Planning Act. These plans identify many current and future water conservation programs. California's agricultural sector has also been developing and implementing ways to reduce on-farm water use. This conservation effort has been broad-based, involving various public institutions, private industries, and farmers. DWR has provided leadership, technical and financial assistance, publications, and supported legislation to promote water conservation in the State. Table 3–3 summarizes current urban and agricultural water conservation programs in place in California. DWR is committed to continue and expand water conservation measures in the future. Current estimates indicate that statewide conservation will save 1.3 million AF of water annually by year 2010. More than half of this savings (700 TAF) would be in the SWP service area.

Other Demand Reduction Measures

The demand reduction measures discussed here are extraordinary conservation options; the water demand reduction options go beyond the conservation measures identified in DWR Bulletin 160–87. Shortage Management Contingency Options (Table 3–4), and long-term options (Table 3–5) are discussed in detail under "South Coast Region."

Demand reduction measures will help offset the 400 TAF shortfall that is expected to occur in dry years by year 2010, assuming that water supply additions and water conservation measures are in place.

Water conservation measures, in conjunction with existing and planned demand reduction measures, would help reduce the water delivery shortfalls projected for year 2010. However, these measures alone will not adequately address the water management issues surrounding the

Table 3-3. Urban and Agricultural Water Conservation Programs

Urban Water Conservation Programs

Landscape Water Conservation. This program promotes water-efficient landscapes by co-sponsoring conferences, assisting water districts in promoting lawn-watering guides, providing information about water-conserving landscape guidelines, and offering training in landscape water management techniques. (1976)

Water Management Planning Assistance. Through this program, DWR has provided assistance to water agencies preparing water management plans. Assistance includes information on how to develop water management program,s, how to schedule the program implementation, and to write and adopt the plan itself. (1983)

Residential Retrofit Program. Technical assistance is provided on how to set up retrofit programs, and offers retrofit kits to communities facing a water emergency. (1977)

Low Interest Loan Program. This program assists local public agencies that can save water through capital improvements by providing low-interest loans for voluntary, cost-effective, capital outlay water conservation projects. Typical projects include lining or piping irrigation ditches and replacing water mains. (1984–1988)

Water Audits and Leak Detection. Saving water lost to underground leaks is the aim of this program. It offers technical assistance to water agencies for locating leaks and estimating losses from piped water distribution systems. Training and leak detection equipment that can be borrowed at no cost is provided by DWR headquarters and four district offices. (1982)

Conservation Information. Through this program, DWR develops water conservation materials and disseminates this information to various groups. It also assists water agencies, local government, and others in developing or expanding their water conservation public information programs. A news letter, *Water Conservation News,* is published quarterly, providing current information on water conservation programs to local, state, and national levels. (1979)

Water Education. The program works with local water purveyors to implement water education programs for children, offers curriculum materials for kindergarten through high school, and cooperates with local water agencies in sponsoring teacher training workshops. In addition, DWR staff members participate in education fairs, workshops, and conferences exhibiting materials and providing hands-on workshops at these events. (1977)

Industrial Water Conservation. The goal of this program is to develop and implement water saving techniques for industrial processes through identification of generic water use reduction measures that can be applied to industries and industrial processes throughout the State. (1986)

Water Reclamation. This new program is designed to facilitate the implementation of water reclamation programs. It emphasizes bringing potential buyers and sellers of reused water together with regulatory agencies to initiate more water reclamation projects. (1989)

Agricultural Water Conservation Programs

Agricultural Drainage Reduction Program. This program helps growers with improvements in irrigation practices on the west side of the San Joaquin Valley in order to reduce the volume of toxic drainage water, which has to be treated and/or discharged. It provides information to growers to help them determine when to irrigate and how much to apply; evaluates irrigation systems and suggests management changes to improve the efficiency of water applications; and demonstrates how irrigation technologies, such as subsurface drip irrigation and volumetrically controlled furrow irrigation. (1985)

Technical Assistance in Irrigation Management. This area has three basic programs: 1) *Irrigation Systems Evaluations* provide recommendations to irrigation managers on irrigation system management for more uniform distribution of applied water. Six teams of trained technicians travel to growers' fields in mobile labs and provide one-time evaluations of the management of the irrigation system. 2) *Cost-sharing grants* are also available to help water purveyors establish irrigation water management programs for their water users. 3) In addition, an *Irrigation System Evaluation Short Course*—attended by water/irrigation district staff members, growers, irrigation consultants, and turf managers—is given twice a year.

California Irrigation Management Information system (CIMIS). This program uses an automated electronic weather station network to provide real-time evapotranspiration (ET) information to growers statewide., Weather data are recorded by more than 50 weather stations throughout California and transmitted daily by telephone to the central CIMIS computer. The central computer estimates the ET rate of irrigated pasture at each weather station site. The ET rate multiplied by a crop coefficient results in an estimate of the crop's ET. Accumulated crop ET can be used to help make decisions on when to irrigate and the amount of water needed to replenish soil moisture. (1980)

Table 3–4
M&I Shortage Contingency Options in the South Coast Region
(In expected order of Use)

Option	Maximum Potential Effect	Use Constraints
1. Institute public relations campaign to heighten conservation awareness, use alternate–day watering, gutter–flooder patrols, etc.	7% of demand	Implementation limited if local stored water situation is excellent compared to shortage.
2. Cut back on deliveries to MWD member agencies for ground water recharge through spreading.	140 TAF[1]	Frequency of cutbacks affects participation in interruptible program.
3. Purchase emergency imported supply through long–term water marketing agreement.	50 TAF	Purchase frequency not to exceed once every five years.
4. Cut back on deliveries for ground water recharge through in–lieu agreement with with MWD member agencies.	35 TAF	Frequency of cutbacks affects participation in interruptible program.
5. Cut back on deliveries to MWD member agencies for reservoir carryover storage.	175 TAF	Frequency of cutbacks affects participation in interruptible program.
6. Use local reservoir carryover storage.	As available	Rule curve limits use.
7. Use local ground water banked within the service area in previous year.	As available	Rule curve limits use.
8. Use local ground water banked through an exchange agreement with another agency.	As available	Rule curve limits use.
9. Cut back on deliveries to MWD member agencies made under the interruptible agricultural delivery program.	74 TAF	Cut back only after shortage in previous year and 3–year cumulative cut not to exceed 100%.
10. Cut back on deliveries to MWD member agencies made under the interruptible sea water intrusion barrier program.	50 TAF	3–year cumulative cut not to exceed 100%
11. Institute a rationing program designed to minimize adverse economic impacts (provide for business exemptions based on economic hardship).	NA	Not imposed unless 20% shortfall remains after foregoing measures.

[1]thousand acre–feet

Delta or the projected needs of the State's growing population. In addition, water supply and demand reduction measures, alone, will not meet NDP objectives because:

- they will not provide for operational flexibility of the SWP. Additional operational flexibility of the SWP can achieve winter banking and provide for fishery benefits in the south Delta.
- they will not provide the required improvements in water quality, water level, or circulation patterns in the south Delta.

For these reasons, the NDP preferred alternative, in conjunction with continued and increased use of water conservation and reclamation practices, is needed to meet the multi-objective goals planned for the Delta.

Analysis of Water Supply and Demand Reduction Alternatives

The analyses that follow were prepared by region. Because of the detailed information available for the South Coast Region and its relative importance, a sophisticated risk management analysis of this region was used and is described briefly here and in detail in Appendix E. The approaches used for the other regions were less comprehensive and are therefore less detailed (see Figure 4-5).

The water supply and demand reduction alternatives examined in this analysis are nonstructural and structural alternatives that are in addition to the 1.3 MAF of demand reduction assumed in the calculation of water supply need.

The purpose of this analysis is to project strategies that may be employed by local agencies as part of their "shortage management." Since no single alternative will meet the shortage, the benefits and risks of the water supply and demand reduction alternatives are weighed against those of the NDP to determine the combination of alternatives that maximizes benefits and maintains an acceptable level of economic risk.

South Coast Region

South Coast Region alternatives were evaluated by predicting what reasonable water management programs in the region would look like both with and without the availability of the proposed facilities.

The approach taken in this analysis takes a comprehensive view of water supply reliability, incorporating key information on the frequency, size, and impacts of shortages. Local water managers (and users) must respond primarily to actual year-to-year fluctuations in water supply availability rather than to an average supply. As shortages increase in magnitude and regularity, shortage management becomes an increasingly important tool for the local water manager. Shortage management contingency options have been incorporated in the economic risk management analysis prepared for the NDP.

The analysis also incorporates a means to account for the value of avoiding extreme shortage events. Summary statistics, such as firm and average yield, do not reflect that one event of a specified shortage amount can be much more damaging than two events of half that magnitude, for example. This is particularly true when there are intervening years of no shortfall in the latter situation and when shortage management can mitigate some of the impacts of the smaller shortages.

Looking at year-to-year water supply availability in the context of what local shortage management contingency options can and cannot do to mitigate adverse impacts, and relating those impacts to shortages of specific sizes, is critical to assessing the value of enhanced reliability. This is especially important in light of the increasing environmental and economic costs of enhancement. The economic risk analysis evaluates the economic feasibility of the level of reliability enhancement provided by any combination of facilities in light of the shortage management techniques locally available.

Local water management program options were divided into three categories:

- shortage contingency demand management and supply enhancement options;
- long-term demand management and supply enhancement options; and
- risk management

Shortage Management Contingency Options. Contingency water management options are measures implemented during shortages only (although they may be based on long-term plans and/or agreements) and are intended to minimize the impacts of those shortages. Such measures include 1) use of banked local ground water, 2) use of local carry-over storage, 3) reduction of water deliveries to interruptible programs, 4) purchasing water to augment normal sources of supply, 5) instituting extraordinary conservation measures, and 6) rationing.

The extraordinary conservation measures include: alternate-day watering, water patrols, emergency water pricing programs, and intensive public education campaigns.

Rationing is assumed to include the setting of allowable use quantities and the provision for exemptions due to extraordinary hardship for residential users and adverse economic impact (e.g., forced layoffs) for businesses due to the severity of the shortage.

See Table 3-4 for a list of shortage management contingency options, the limit of their effect on demand, and their expected order of use. These options are assumed to be available in the South Coast Region throughout the study period.

Long-Term Options. Local long-term water management options to increase reliability that were considered included 1) waste water reclamation, 2) desalinization of brackish drainage and ground water, 3) desalinization of sea water, and 4) the development of water by importation, using long-term conservation facilities in other geographic areas. Also included was the retrofit with ultra low-flush toilets and leak detection programs in the service area. All these programs are extraordinary measures; i.e., they are beyond those assumed to be used in DWR Bulletin 160-87 and are intended to develop and/or conserve water continuously.

Table 3-5 is a summary list of local long-term options assumed to be available in the South Coast Region. For the year 2000, it was assumed that reclamation projects now in the conceptual stage—rather than in the planning stage—would not be available. The options are ranked in the assumed order of implementation (based on using those with the lowest unit cost first). The water reclamation options are weighted average values for individual projects. The options are described in the following paragraphs and are also described in detail in Appendix E.

Unit cost, water produced or conserved by each option, and cumulative quantities are also shown in Table 3-5. Costs shown are in 1989 dollars and are computed using noninflated dollars and a 6 percent discount rate. The energy cost component of each alternative is assumed to escalate at 1.7 percent per year during the study period. These criteria, which are used to compare alternatives, are consistent with those used for developing the costs of the proposed SWP action.

1. ***Water Reclamation (Set 1). See Appendix E.*** For year 2000, no projects are available in this group. For the period 2010 to 2035, it includes three projects producing a total of 23,000 acre-feet (TAF). The weighted average cost of these projects is $117 per AF.
2. ***Water Reclamation (Set 2). See Appendix E.*** For the period 2000 to 2035, this option includes two projects producing a total of 13 TAF at a weighted average cost of $224 per AF.
3. ***Residential water audits*** would be conducted by water agency representatives as a result of aggressive pro-

Table 3-5
Local Long-Term Options — South Coast Region

Order of Use	Local Option Type	Product (TAF) 2000	2010	2035	Cumulative Product (TAF) 2000	2010	2035	Unit Cost ($/AF)
1[1]	Water reclamation (set 1)	0	23	23	0	23	23	117
2[1]	Water reclamation (set 2)	13	13	13	13	36	36	224
3	Residential water audits	95	95	95	108	131	131	291
4[1]	Water reclamation (set 3)	49	59	59	157	190	190	350
5	Ultra low flush toilet retrofit	290	290	290	447	480	480	357
6	South Coast ground water desalting	78	78	78	525	558	558	386
7	Imperial drainage water desalting	301	302	302	827	860	860	417
8	San Joaquin Valley drainage water desalting	164	214	337	991	1,074	1,197	427
9	Water reclamation (set 4)	9	22	22	1,000	1,096	1,219	441
10	Riverside County drainage desalting	42	42	42	1,042	1,138	1,261	468
11	Water reclamation (set 5)	1	30	30	1,043	1,168	1,291	618
12	Water reclamation (set 6)	19	32	32	1,062	1,200	1,323	781
13	Sea water desalting	5	5	5	1,067	1,205	1,328	1,783

[1]These groupings are based on unit cost; for more details, see Appendix E.

motional campaigns by the water agency. The audits are free to the property owner but they are voluntary; thus the number of households benefiting from the audit was estimated at 50 percent. Under the program: 1) water uses are identified and discussed with householders, 2) low-flow shower heads, toilet tank displacement dams, and faucet aerators are offered for installation by the agency, 3) toilet leaks are repaired, and 4) advice on reducing landscape and other exterior water uses is provided. Water savings are estimated to be 94,700 AF per year.

4. ***Water Reclamation (Set 3). See Appendix E.*** For year 2000, this option includes six projects producing 49 TAF. For the period 2000 to 2035, this option includes seven projects producing a total of 59 TAF. The weighted average cost of these projects us $350 per AF.

5. ***Ultra-low-flush toilets*** use 1.6 gallons per flush (gpf), compared to about 5.5 gpf for conventional toilets installed before 1978 and 3.5 gpf (low-flush) toilets installed beginning in 1978. (State legislation requires the installation of 3.5 gpf toilets after 1977.) For Bulletin 160-87, it was assumed that 1.6 gpf toilets would be required in all new construction after January 1, 1995. State legislation is pending. If most 5.5 gpf toilets were replaced with 1.6 gpf toilets, at a minimal savings of 0.018 AF per person per year, the potential savings is 290 TAF per year. This program would require a 10-year conversion period.

6. ***South Coast Region Ground Water Desalting.*** Locations and quantities of desalted water potentially available from this source are:

County	Annual Yield (AF)
Ventura	10,000
Los Angeles	12,000
Riverside	17,000
San Diego	20,000
San Bernardino	19,000
Total	**78,000**

7. ***Imperial Drainage Water Desalting.*** Imperial Irrigation District could use desalted agricultural water in lieu of Colorado River deliveries. As with the Imperial Valley conservation and transfer alternative, Metropolitan Water District would then divert a corresponding amount from the Colorado River Aqueduct. The costs of desalting and transportation through the aqueduct were taken into account. The cost of substituting poorer quality Colorado River water for urban use, was not considered.

8. ***San Joaquin Valley Drainage Water Desalting.*** A program of desalting brackish agricultural drainage water would allow further local reuse of that water as a substitute for water imported from the Delta so that more water would be available to Southern California. Whereas the quality of imported water (280 mg/l TDS) would differ from that of the desalting product water (500 mg/l TDS), blending small desalting product water flows with the very much larger imported water flows would make little difference until the amounts of desalting product water reached very high levels.

   Due to the complexity of the water transfer facilities, no attempt has been made to calculate those differences, even with the maximum potential flows of desalting product water. The estimated potential annual yield of desalted drainage water is 164 TAF/YR in 2000, increasing to 337 TAF/YR in 2035. This assumes that only drainage water from the Tulare Lake Basin is totally captured for desalting. Drainage water in the San Joaquin Basin will probably continue to be discharged to the San Joaquin River as long as water quality objectives in that river are met. To the extent that the available drainage water will be either reused for agriculture, used for ground water management, or discharged to evaporation ponds, it will be unavailable for desalting.

9. ***Water Reclamation (Set 4). See Appendix E.*** For year 2000, this option includes four projects producing 9.0 TAF. For the period 2010 to 1035, this option includes ten projects producing 22 TAF. The weighted average cost of these projects is $441 per AF.

10. ***Riverside County Drainage Water Desalting.*** Water provided from this source was assumed to be available for agricultural reuse in Coachella Valley. Estimated yield is 42 TAF/YR by 1990 and thereafter. The cost of this option includes conveyance facilities for the desalted water and pumping for reuse, and for conveying exchange water from the Colorado River to the South Coast Region.

11. ***Water Reclamation (Set 5). See Appendix E.*** For year 2000, this option includes one project producing 1.0 TAF. . For the period 2010 to 2035, this option in-

cludes nine projects producing 30 TAF. The weighted average cost these projects is $618 per AF.

The small benefit to irrigated agriculture of using higher quality desalted water (500 mg/l TDS) rather than Colorado River water (700 mg/l TDS) was not subtracted from the cost of this alternative because of complexities such as leaching requirements. Estimated yield is 302 TAF by 1990 and thereafter.

12. ***Water Reclamation (Set 6).*** See Appendix E. For year 2000, this option includes three projects producing a total of 19 TAF. For 2010 to 2035, the option includes six projects producing 32 TAF. The weighted average cost of these projects is $781 per AF.

13. ***Sea Water Desalting.*** In sea-water desalting, reverse osmosis (RO) is now competitive with more traditional forms of desalination, even in the case of a dual-purpose project involving both power production and desalting. In the past, desalting combined with power production almost automatically meant a distillation process using waste heat from the power plant. This is no longer true for the current RO plant designs with improved membranes and energy recovery turbines.

Risk Management. Another long-term management strategy evaluated was the explicit evaluation of risk with regard to the optimal level of use of the long-term management options. Using this strategy calls for explicitly evaluating the economic cost of shortages based on their expected frequency and magnitude and in the light of available contingency shortage management measures. The results of that evaluation are then used in conjunction with an analysis of the cost and effectiveness of available long-term water management measures to determine which of these measures are reasonable from an economic standpoint. DWR provided testimony regarding the benefits of using this approach during the recent SWRCB Bay-Delta Hearings (DWR 460).

Tulare Lake Region

Agricultural Users. For individual farmers using SWP agricultural deliveries in this region, local options for water supply and demand management include:

- Pump ground water (if farm overlies a ground water basin).
- Increase on-farm water application efficiency.
- Exchange supplies within the local water agency from areas with alternative supplies to those without.
- Stress crops by not meeting full evapotranspiration requirements.
- Reduce planted acreage of annual crops.

Based on the 1976–77 drought experience, which included the drilling of many additional wells, it is reasonable to expect that any additional increment to SWP delivery curtailments due to the absence of the NDP will be compensated by local ground water pumping. For areas that do not overlie ground water, the 1976–77 experience demonstrated local water agency flexibility in setting up contingency exchanges with those areas with available supplies.

Reinforcing this expectation is the fact that potential net water savings from increased on-farm efficiency in the Tulare Lake region are small to non-existent because of already high on-farm and basin efficiencies. In addition, crop stressing is a high-risk strategy and leaving non-program farmland idle is costly.

The cost of using ground water as an alternative in the Tulare Lake Region includes the cost of energy for the additional pumping in the year of curtailment related to the absence of the NDP and the cost of managing any exchange programs necessary to get additional water to areas without groundwater pumping capability. Also, because the Tulare Lake Region is in a condition of long-term groundwater overdraft, the additional pumping in any single year will cause an increase in pumping depth, which will result in a long-term increase in all pumping costs. A conservative estimate of these pumping costs impacts made for this report is $75 per AF. This estimate was based on a March 1985 DWR San Joaquin District Memorandum Report, *A Method for Estimating the Value of Surface Water in Conjunctive Use Areas*.

Because of the long-term overdraft, the absence of the NDP will accelerate the point at which agricultural ground water pumping becomes uneconomical, or water quality becomes unacceptable for crop production. The net economic cost of the future loss of irrigated acreage was assumed to be at least as costly as the ground water pumping alternative described above.

M&I Users. SWP M&I users in the Tulare Lake Region were assumed to have the same capability for ground water pumping and/or contingency exchange as the agricultural users in the region. The cost of these alternatives to the M&I users was assumed to be at least as high at the current cost of the M&I supply minus the cost of local treatment and delivery. This value was estimated to be $230/AF based on a DWR water price survey.

Sacramento River Region

The M&I water users in this region are assumed to have access to local surface water as a supply management option. Using the weighted average SWP equivalent unit water cost of $21 per AF as a conservative alternative cost, DWR assumes that the cost of using the alternative supplies is at least as great as the cost of the current SWP supply. DWR Bulletin 132-89, *Management of the California State Water Project,* November 1989, was the source of the equivalent unit cost.

South Lahontan Region

SWP deliveries are made to this region for both agricultural and urban uses. Because of the rapid urbanization taking place and the absence of supply options, urban users depend on both the phasing out of local agriculture and an increase in SWP deliveries to meet their future needs. Even with the use of additional local water exchanges and extraordinary shortage-management programs, the growth in urban demands will result in even more frequent and severe economic losses due to shortages. Without the NDP, this situation would be worsened.

Colorado River Region

Water management options in this region include additional waste water reclamation and water sharing with agricultural users on a contingency basis. The frequency and extent of sharing would have to be restricted to avoid unacceptable economic impacts within the agricultural sector. The acceptance of additional economic risk would also be a likely consequence of the absence of the NDP.

San Francisco Bay Region

Water management options in this region include additional wastewater reclamation, water exchange agreements among local water agencies, and the acceptance of additional economic risk. It is reasonable to assume that the value of the alternatives will exceed the current value of urban water of about $440 per AF. This value was obtained from a DWR water price survey.

Central Coast Region

The situation in this region is characterized by costly water supply options in the face of increasing use due to population pressure. After assuming extraordinary conservation measures, consisting of an ultra-low flush toilet retrofit program and residential water audits, a combination of local water supply options will be required to meet urban demands. These options include reservoir construction ($800 per AF), pipeline construction ($435 per AF) and sea-water desalinization ($2,140 per AF). This conclusion was the result of research conducted for the Coastal Aqueduct EIR being prepared by DWR. In light of those costs, it seems reasonable to assume that shortage contingency demand and supply management strategies similar to those used for the South Coast Region analysis would be applicable to this region. Accordingly, the cost of local alternatives in this region were assumed to be proportional to those determined for the South Coast Region—about $800,000 annually.

Analytical Approach for South Coast Region

For the purpose of evaluating the alternatives to the NDP, it was assumed that the shortage management contingency options available would be those which could reasonably be expected to be available during the study period using the criteria of physical and political feasibility. Because the same options would be used under conditions both with and without the NDP—their use dictated by the severity and duration of shortages—they can be considered as alternatives to the NDP only in terms of the frequency and extent of their use. It was also assumed that a risk management strategy, as described above, would be applied, whether or not the NDP was in place. Two of the alternative configurations of the NDP were evaluated, 2A and 5B. Both evaluations assumed no SDP facilities in place.

This approach required the use of a simulation model that would approximate, to a reasonable degree, the use of local contingency measures which would actually be seen in response to shortages of various sizes and durations. The economic cost of shortages could then be determined by tying implementation costs to the use of these measures and adding these to an estimate of the economic losses which would be incurred by water users after all reasonable mitigation measures were employed. For this study, the value of losses to users was derived from the current marginal cost of water to residential users and a recent residential user survey on the willingness to pay to avoid water shortages.

Table 3-6 shows the relationship between potential water shortages to households as a percentage of normal use and the median willingness to pay to avoid such shortages. These values were used in the simulation model in functional form to estimate losses.

Figure 3-7 is a flow chart of the Economic Risk Model. Appendix E contains a detailed description of the logic of the model, the parameters used, and the general assumptions.

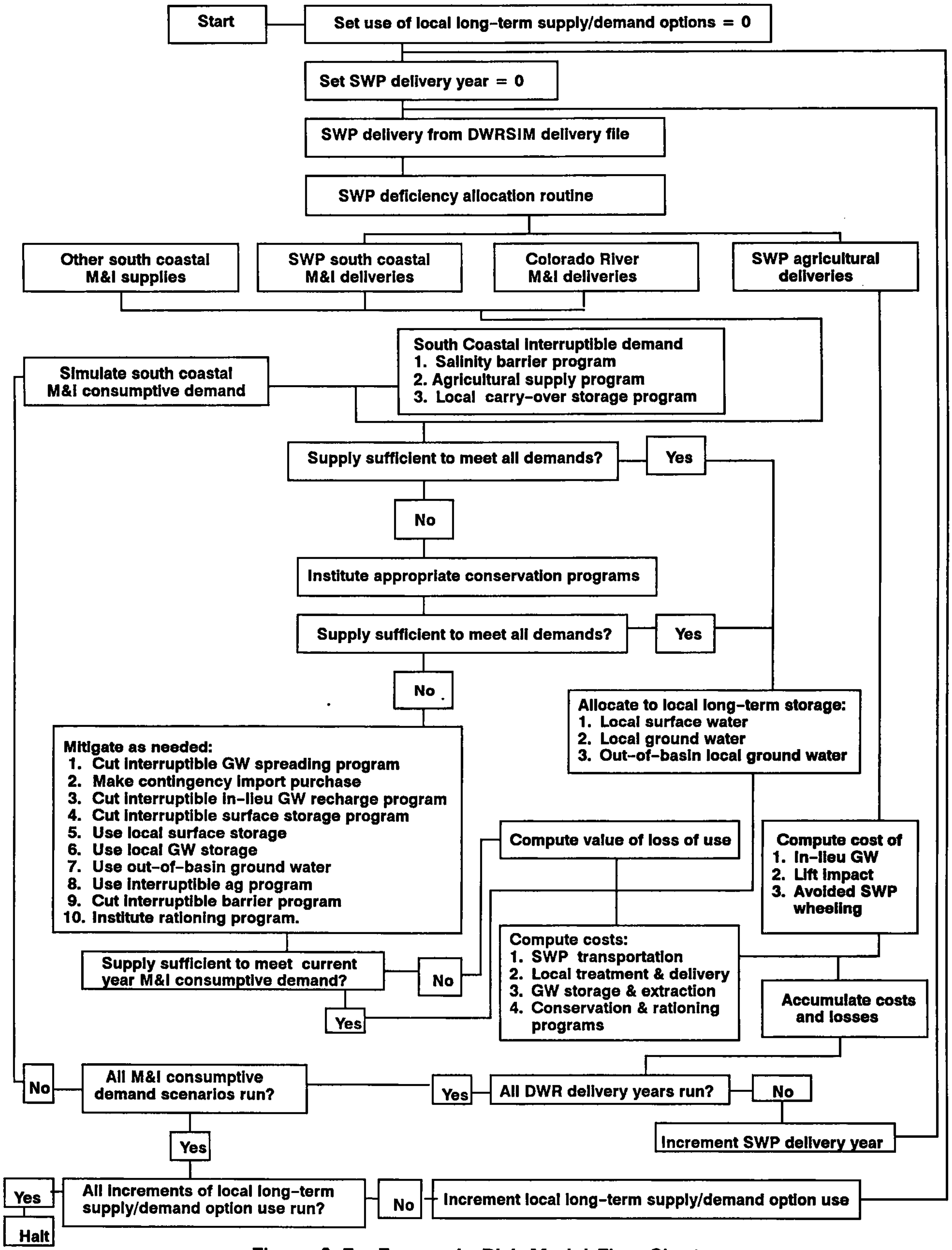


Figure 3-7. Economic Risk Model Flow Chart

Table 3-6 Willingness to Pay ($ per household)			
Sufficiency Ratio	Acre-feet/ year per Household		
	0.75	0.65	0.50
.95	$25	$22	$17
.90	76	66	51
.85	151	131	101
.80	249	215	166
.75	366	317	366
.70	502	435	355
.65	654	567	436

In brief, the model was run on the 57-year hydrologic record for both year-2000 level demands and year-2035 level demands. The operational considerations cited previously, with the exception of the future operation of KWB and LBG, were applicable. Two sets of runs were made at each demand level; the only difference was the existence of the NDP: one set assumed their existence, whereas the other set did not. Within each set, runs differed only by the amount of additional water made available by the use of local extraordinary long-term water supply enhancement and demand management options. Runs were made using increments of 20 TAF of additional local water up to a total of 1 million acre-feet.

Average M&I consumptive use for the South Coast Region was based on numbers produced for DWR Bulletin 160-87, *California Water: Looking to the Future,* November 1987. The numbers from Bulletin 160-87 were updated in accordance with regional population allocations developed by DWR from statewide interim projections produced by the Department of Finance for years 2000 and 2010. These interim projections were also used by DWR to update the 2035 projection appearing in the *Draft South Delta Water Management Plan EIR/EIS,* June 1990, for the South Coast Region.

Variation in the year-to-year level of M&I consumptive use was simulated within the ERM based on historic climatic conditions in the South Coastal Region during the 57-year period of hydrologic record. The variance in consumptive use driving the simulation was based on an estimate made in a study conducted for The Metropolitan Water District of Southern California by Chesnutt and McSpadden: *Statistical Analysis of Water Demands During the Current Drought,* January 1989. Each run (at a specified increment of local supply) was made 30 times for each of the 57 years of hydrologic record. This allowed for the resimulation of consumptive use each time to derive a sufficiently reliable estimate of the expected value of the economic loss.

For each of these runs, an expected economic loss was computed and compared to the cost of the local extraordinary long-term water management options used. On this basis, an optimal use of these options could be established using the risk management criterion. Because risk mitigation is not costless, this level of optimal use of local management options still allows for an associated level of expected losses. Any further reduction in expected losses would not be cost-effective compared to the higher cost of the remaining options.

Table 3-7 shows how the economic risk model run results were used to identify those local options that would no longer be needed under the risk management criterion if the NDP were in place. For each of the study years, the option, part of the option, or combination of options no longer needed—along with the acceptance of additional risk—is properly designated as the alternative to the NDP. For each study year, the first column shows the use in thousands of acre-feet of local options without the NDP available. The second column shows the effect of the NDP on total local option use. The third column shows the change in local option use attributable to the NDP—the NDP local option use alternative.

Economic Benefits

Economic benefits of the proposed NDP were determined by using the Economic Risk Model directly for the South Coast Region and SWP agriculture contractors in Kings and Kern counties. The model results were used indirectly for the Central Coast Region. Current water costs were used to estimate willingness to pay for water in the San Francisco Bay, Tulare Lake, and Sacramento River region.

South Coast Region Benefits

The benefits of the NDP for the South Coast Regions depend on the extraordinary local water supply and demand management options that would be employed under conditions with and without the proposed NDP. Either the costs of the options which could be displaced by the existence of the proposed NDP, the expected economic losses which would be avoided with the proposed NDP, or both (if appropriate), could then be properly attributed to the NDP facilities as benefits.

Table 3-8A and 3-8B were developed by using the procedure described in the previous section for determining the

Table 3–7

Local Service Area Alternatives, Local Long–Term Option Use—South Coast Region (TAF)

Local Option ID[1]	Available Product 2000	Available Product 2010	Available Product 2035	Year 2000 Without Project	Year 2000 With Project	Year 2000 Option Use Alt.	Year 2010 Without Project	Year 2010 With Project	Year 2010 Option Use Alt.	Year 2035 With Project	Year 2035 Without Project	Year 2035 Option Use Alt.
NDP Alternative 2A												
WR1	0	23	23	0	0	0	23	23	0	23	23	0
WR2	13	13	13	13	13	0	13	13	0	13	13	0
RWA	95	95	95	95	95	0	95	95	0	95	95	0
WR3	49	59	59	49	49	0	59	59	0	59	59	0
ULFTR	290	290	290	165	104	61	257	214	43	290	290	0
SCR GWD	78	78	78	0	0	0	0	0	0	78	78	0
IID DWD	302	302	302	0	0	0	0	0	0	232	186	46
SJV DWD	164	214	337	0	0	0	0	0	0	0	0	0
WR4	9	22	22	0	0	0	0	0	0	0	0	0
RC DWD	42	42	42	0	0	0	0	0	0	0	0	0
WR5	1	30	30	0	0	0	0	0	0	0	0	0
WR6	19	32	32	0	0	0	0	0	0	0	0	0
SWD	5	5	5	0	0	0	0	0	0	0	0	0
Total Quantity Used/Displaced				**322**	**261**	**61**	**447**	**404**	**43**	**790**	**744**	**46**
NDP Alternative 5B												
WR1	0	23	23	0	0	0	23	23	0	23	23	0
WR2	13	13	13	13	13	0	13	13	0	13	13	0
RWA	95	95	95	95	95	0	95	95	0	95	95	0
WR3	49	59	59	49	49	0	59	59	0	59	59	0
ULFTR	290	290	290	165	47	118	257	184	73	290	290	0
SCR GWD	78	78	78	0	0	0	0	0	0	78	78	0
IID DWD	302	302	302	0	0	0	0	0	0	232	161	71
SJV DWD	164	214	337	0	0	0	0	0	0	0	0	0
WR4	9	22	22	0	0	0	0	0	0	0	0	0
RC DWD	42	42	42	0	0	0	0	0	0	0	0	0
WR5	1	30	30	0	0	0	0	0	0	0	0	0
WR6	19	32	32	0	0	0	0	0	0	0	0	0
SWD	5	5	5	0	0	0	0	0	0	0	0	0
Total Quantity Used/Displaced				**322**	**204**	**118**	**447**	**374**	**73**	**790**	**719**	**71**

[1]See Table 3–5.

optimal employment of local options and noting the expected loss values associated with each level of use of the options.

It is important to note that the lower the use of the local options, the higher the value of the NDP for reducing risk. The avoided economic loss benefit of the NDP would be more than proportionally greater to the degree that the extraordinary local options are not available or are more costly than assumed—an important observation because of the uncertainty about the environmental, legal, and health aspects problems associated with some of the options.

The analysis, based on marginal value of expected losses avoided equated to marginal costs of local water supply/demand management options, is a conservative way of interpreting the model results with respect to estimating the benefits of the NDP. If local water managers (and users) are more risk–averse than indicated by this type of analysis—which is a reasonable assumption—the benefits will be higher than indicated. Under the assumption of greater risk–aversion, the avoided cost of the local options that would be displaced by existence of the facilities becomes more important. Because it is the increasingly costly options that would be displaced, the cost savings (i.e., benefits) arising from use of the facilities to attain the desired level of risk become very large.

The conservative assumption of a linear build–up in demand between year–2000 and year–2035 demand levels was made to facilitate the computation of the equivalent annual benefits over the study period. This value for the South Coast Region was determined to be $22.2 million

Table 3–8A
Annual Economic Benefits of North Delta Water Management Program, South Coast Region, Alternative 2A ($ millions)

Benefit	Demand Level 2000	2010	2035
Change in avoided losses due to reduction in use of local options	–26.0	–18.2	–32.6
Avoided local option costs	21.9	16.4	29.1
Net gain from reduction in use of local options	–4.1	–1.8	–3.5
Benefit of NDP at reduced local option use	17.9	21.1	40.5
Adjusted benefit of NDP	13.8	19.3	37.0

Table 3–8B
Annual Economic Benefits of North Delta Water Management Program, South Coast Region, Alternative 5B ($ millions)

Benefit	Demand Level 2000	2010	2035
Change in avoided losses due to reduction in use of local options	–57.9	–32.4	–53.2
Avoided local option costs	41.8	27.0	44.6
Net gain from reduction in use of local options	–16.1	–5.4	–8.6
Benefit of NDP at reduced local option use	45.7	42.8	69.7
Adjusted benefit of NDP	29.6	37.4	61.1

with Alternative 2A and $41.2 million with Alternative 5B. The linear build-up is assumed to be conservative because of the nature of population growth in the area.

Agricultural Benefits for SWP Service Areas in Kings and Kern Counties

The Risk Model results were used directly for this benefit computation because of the conservative simplifying assumption that benefits are constrained to the alternative cost of pumping in lieu of SWP agricultural deliveries.

This was felt to be conservative because facilities to bring ground water through intra-agency exchanges are not available for all areas which do not overlie ground water. In addition, the consequences of relying on in-lieu pumping in areas with critical overdraft problems were not addressed by this analysis.

The model runs produced the following results for agricultural losses adjusted for the avoided SWP transportation costs (Table 3–9).

Based on this approach, the expected equivalent annual benefits were calculated to be $1.4 million for Alternative 2A and $2.7 million for Alternative 5B.

Benefits in Other SWP M&I Service Areas

The Economic Risk Model has not been applied directly to other SWP municipal and industrial areas because the necessary information on either the reliability or cost of local supplies, the availability and effectiveness of local water supply, and demand management options was unavailable. The following regions were those in which the major portion of the NDP benefits were expected to occur.

Central Coast Region. The situation in this area is characterized by costly water supply options in the face of rising use due to population pressure. On the basis of this knowledge, it was felt to be conservative, with respect to the value of the proposed NDP, to apply the benefits and results determined for the South Coast Region to this area. This was done by assuming benefits in proportion to relative entitlement. This amount was determined to be

Table 3–9 Annual Agricultural Benefits ($1,000)		
	Year	
	2000	2010–2035
Alternative 2A		
Expected agricultural losses		
without NDP	19,945	25,431
with NDP	18,408	24,022
Avoided losses	1,537	1,409
Alternative 5B		
Expected agricultural losses		
without NDP	19,945	25,431
with NDP	17,126	22,842
Avoided losses	2,819	2,589

about $600,000 annually for Alternative 2A and $1.2 million annually for Alternative 5B.

San Francisco Bay Region. Average urban water rates in the North Bay SWP service area are presently about $445 per AF. For the South Bay this figure is about $415 per AF. Adjusting these values for local treatment and delivery cost plus SWP conveyance, would translate them to about $390 and $360 per AF, respectively, at the Delta. Assuming these values to be year 2000–level values is conservative. For 2035, it was assumed that they would rise linearly from year 2000 to $500 per AF, less than is currently being paid in Southern California high–cost areas. Using an average increment of yield from the proposed project to this area of 4.8 TAF in 2000, rising to 7.4 TAF in 2035, the benefit value was computed to the equivalent of about $1.8 million annually for Alternative 2A and $3.5 million for Alternative 5B.

Tulare Lake Region. The average urban water rate presently being paid for urban water in this area is $268 per AF. Adjusting this for SWP conveyance cost and local treatment and distribution results in a net value of $230 per AF. This value was assumed to remain constant throughout the study period. An average increment of yield from the proposed facilities to this area of 2.1 TAF in 2000, and rising to 3.9 TAF in 2035, was used to estimate benefits. Based on this, an equivalent annual value of $600,000 was obtained for Alternative 2A and $1.0 million annually for Alternative 5B .

Summary of Annual Benefits

The following compilation column shows the benefits derived with the procedures described above. Total benefits of the NDP were estimated to be about $27 million annually for Alternative 2A and about $50 million annually for Alternative 5B.

Region	Annual Benefit ($ millions)	
	Alter. 2A	Alter. 5B
M&I		
South Coast	22.2	41.2
Central Coast	0.6	1.2
San Francisco Bay	1.8	3.5
Tulare Lake	0.6	1.0
Subtotal	**25.2**	**46.9**
Agricultural		
Tulare Lake	1.4	2.7
Total	**26.6**	**49.6**

The average annual cost of additional yield provided by the NDP depends upon the capital cost of project construction, annual project maintenance, and transportation costs. The the transportation costs are highest for the South Coast Region and are taken into account when the benefits for this area were calculated.

For Alternative 2A the estimated cost of water delivered to the South Coast Region is about $100 per acre foot. With an average annual yield of 75 thousand acre feet (TAF), the annual cost of the project, with transportation cost included, is about $7.6 million and the benefit/cost ratio is about 11.6.

For Alternative 5B, the preferred alternative, the estimated cost of water delivered to the South Coast Region is about $240 per acre foot. With an average annual yield of 140 thousand acre feet (TAF), the annual cost of the project, with transportation cost included, is about $33.2 million and the benefit/cost ratio is about 2.1.

Summary Alternative Analysis

A detailed environmental impact analysis is described in Chapter 5 and summarized in Table 3–10, which shows the basis for selection of the preferred alternative.

Table 3-10

ALTERNATIVE SUMMARY TABLE									
	ANALYSIS								
ALTERNATIVE	Alleviate Flooding	Reduce Reverse Flow	Improve Water Quality	Improve Water Supply Reliability	Improve Naviga-tion	Enhance Recreational Opportunities	Enhance Riparian & Wildlife Habitat	Delta Out-Flows	Delta Outflow Pulses
1 No Action									
2A Dredge So.Fork Mokelumne River	+	+	+	+	+	+	0	-	0
2B Dredge So.Fork Mokelumne River & Enlarge Cross Channel Gates	+	++	++	++	+	+	0	-	0
3A Dredge So.Fork & No.Fork Mokelumne River	++	+	+	+	+	+	0	-	0
3B Dredge So.Fork & No.Fork Mokelumne River & Enlarge Cross Channel Gates	++	++	++	++	+	+	0	-	0
4A Enlarge So.Fork Mokelumne & Dredge No.Fork Mokelumne River	+++	+	+	+	++	+++	+++	-	0
4B Enlarge So.Fork Mokelumne River, Dredge No.Fork Mokelune River, & Enlarge Cross Channel Gates	+++	+++	+++	+++	++	+++	+++	-	0
5A Enlarge No.Fork Mokelumne River & Dredge So.Fork Mokelumne River	+++	+	+	+	++	+++	+++	-	0
5B Enlarge No.Fork Mokelumne River, Dredge So.Fork Mokelumne River, & Enlarge Cross Channel Gates	+++	+++	+++	+++	++	+++	+++	-	0
6A Create an Island Floodway	++++	+	+	+	0	++	--	-	0
6B Create an Island Floodway and Enlarge the Cross Channel Gates	++++	+++	+++	+++	0	++	--	-	0
7 Conservation, Reclamation, Desalinization, and Acceptance of Increased Risk	0	0	0	+++	0	0	0	0	0

[shaded box] Preferred Alternative

Key:
- \+ Beneficial Impact
- 0 Insignificant Impact
- \- Adverse Impact
- U Unknown Impact

Table 3-10 (continued)

ALTERNATIVE SUMMARY TABLE										
	ANALYSIS									
Altern-ative	Municipal & Indus-trial water use	Agricul-tural Water Use	Channel Velocities and Siltation	Levees	Striped Bass Impacts	Salmon and Steelhead	American Shad	Sturgeon	Resident Fish	Fish Food Supply Impacts
1										
2A	+	+	+	+	0	-	-	0	-	-
2B	++	++	+	+	0	0	-	0	-	-
3A	+	+	+	+	0	-	-	0	-	-
3B	++	++	+	+	0	0	-	0	-	-
4A	+	+	++	+	0	-	0	0	0	+
4B	+++	+++	++	+	+	0	0	0	0	+
5A	+	+	++	+	0	0	+	0	0	+
5B	+++	+++	++	+	+	0	+	0	0	+
6A	+	+	+	0	0	--	-	0	0	+
6B	+++	+++	+	0	+	--	-	0	0	+
7	0	0	0	0	0	0	0	0	0	0

Table 3-10 (continued)

ALTERNATIVE SUMMARY TABLE									
	ANALYSIS								
Altern-ative	Rare, Threat-ened and Endangered Species	Tracy Pumping Plant Operation	Suisun Marsh	San Fran-cisco Bay Aquatic Resources	Construc-tion	Socio-Economic/ Growth Impacts	Energy & Capacity Impacts	Archaeo-logical & Cultural Resources	Cost $ Million
1									
2A	+	0	0	U	0	0	-	U	29
2B	+	0	0	U	0	0	--	U	59
3A	+	0	0	U	0	0	-	U	53
3B	+	0	0	U	0	0	--	U	83
4A	++	0	0	U	0	0	-	U	368
4B	++	0	0	U	0	0	--	U	398
5A	++	0	0	U	0	0	-	U	260
5B	++	0	0	U	0	0	--	U	290
6A	0	0	0	U	0	0	--	U	250
6B	0	0	0	U	0	0	--	U	280
7	0	0	0	0	0	0	0	0	780

Alternatives Rejected From Further Consideration

This section discusses the alternative plans investigated in the past to meet some NDP objectives.

Peripheral Canal

The Peripheral Canal was proposed in the late 1960s as a joint-use facility of the SWP and CVP. The objective of the project was to convey good quality water from the Sacramento River to the existing SWP and CVP pumping plants for export and to 12 release facilities to distribute water from the canal to Delta channels to maintain water quality within prescribed criteria and to improve the Delta aquatic environment and the resources and economies it supports. However, voters rejected Proposition 9 (Senate Bill 200) in June 1982, making advocacy of the plan impractical.

Some of the benefits the canal could have had on the north Delta are discussed here. Additional information can be found in the *Draft Environmental Impact Report, Peripheral Canal Project, DWR,* August 1974.

As it crossed the San Joaquin, Middle, and Old rivers, the Peripheral Canal would have released good quality water into each of them. This would have provided water of adequate quality in the south Delta in coordination with the environmental needs of the fishery.

In addition, the Peripheral Canal would have eliminated direct pumping from the south Delta channels in all but periods of high San Joaquin River flows. Thus, the adverse impacts of SWP and CVP operations on water levels in the south Delta would have been eliminated.

Other Alternatives

In Bulletin 76, *Delta Water Facilities,* DWR, July 1978 a long list of suggested alternatives was analyzed. Subsequently when the Peripheral Canal was defeated, DWR published a report in 1983 focusing on alternative solutions to the Delta water transfer problems. Some of the alternatives analyzed in the 1983 report *Alternatives For Delta Water Transfer* are applicable to the NDP objectives, and they have been considered in some of the NDP alternatives.

One alternative in the 1983 report not considered here is the dual transfer system. A dual transfer system would be a compromise for the many beneficial users of Delta water. Under this concept, about half the water being exported by the SWP and CVP would flow through existing channels and half in a new channel. A new channel would have been built from Hood to Clifton Court Forebay to transfer all SWP flows in all but the high–flow, high–diversion months. This facility could have followed the same alignment as the Peripheral Canal but with only one–third the capacity. Except for small areas to the east, Delta water needs would have been met from flow through existing channels rather than canal releases.

In recent years, drinking water quality has become a growing concern. Organic contaminants have also become an important issue. A May 1989 report, *Delta Drinking Water Quality Study* (Brown and Caldwell, Consulting Engineers), identified water quality problems and management strategies to deal with drinking water quality. The alternatives analyzed ranged from minor modification of water project operations to major modifications of water project facilities. The results of the study show that alternatives that receive water upstream of the Delta would provide drinking water of higher quality than that of the existing supply. The report provides updated information for the Peripheral Canal assessment. In addition, recent analysis by DFG through negotiations (Article VII) has shown favorable aspects for an isolated transfer system.

Chapter 4. ENVIRONMENTAL SETTING

This chapter describes the geographic areas related to the North Delta Water Management Program. Because of the interdependence of water supplies used in the State, these areas include a large part of California. The areas are:

- North Delta Region
- Delta Region
- Suisun Marsh
- San Francisco Bay Area
- Sacramento Valley
- San Joaquin Valley
- State Water Project service areas in North and South San Francisco Bay, Central Coast, San Joaquin Valley, and Southern California

The Sacramento–San Joaquin Delta and San Francisco Bay estuary, comprised of the Delta, Suisun Marsh, and the San Francisco Bay system, supports major populations of fish and wildlife. An overview of the estuary is presented below, followed by specific discussions of each of the areas listed above.

Overview

The 12 counties surrounding the Bay/Delta estuary encompass a diversified and vital metropolitan and agricultural region. The population in these counties is increasing. The estuary supports one of California's most important aquatic ecosystems. The mild temperatures and ample waterways also make it one of the most popular sports fishing and recreational areas in California.

Flowing south, fed by streams in the northern Sierra Nevada, the Sacramento River meets the northbound San Joaquin River to form the Sacramento–San Joaquin Delta in the Central Valley. The two rivers mingle with smaller rivers to form a 700–mile–long maze of rivers and sloughs surrounding over 60 islands and tracts.

Tributary inflow provides for local consumptive use, protective Delta outflow requirements, and exports in the State from the Bay Area to Southern California. Outflows continue westward out of the Delta at Chipps Island, through a gap in the Coast Ranges at Carquinez Strait, and into San Francisco Bay and the Pacific Ocean. Suisun Marsh and adjoining bays are the brackish transition between the fresh water flowing from the rivers and the salt water of the Bay.

The estuary water quality and tidal hydraulics are complex. When Delta outflows meet the higher salinities of the bay and ocean, salinity gradients result from the mixing of fresh water and ocean water. The magnitude and extent of these gradients depend primarily on the magnitude of Delta outflows and ocean tides. As outflows increase, the mixing zone tends to shift seaward, increasing the salinity stratification and compressing the mixing zone.

Other factors affecting the estuary water quality and hydraulics include channel geometry, wind, barometric pressure, local and project diversions, agricultural drainage, pollutant discharges, and ambient temperature. Organisms inhabiting the Bay also vary with time and location, in response to changes in flow and water quality, ranging from those tolerant of ocean salinities, to those only tolerating freshwater, to those estuarine organisms that have developed a tolerance to widely varying salinities.

San Francisco Bay consists of four embayments – Suisun Bay, San Pablo Bay, Central Bay, and South Bay. Hydraulic conditions in the system are primarily controlled by tides and freshwater inflow. Tides originating in the Pacific Ocean enter San Francisco Bay through the Golden Gate, where the average tidal range is 5.7 feet. The volume of water entering and leaving the bay system during each 6.2 hour flood or ebb tide averages about 1.1 million acre–feet (MAF).

The major source of fresh water in San Francisco Bay is outflow from the Delta. Delta outflows vary greatly according to month and hydrologic year type. Delta outflow has averaged 24 MAF over the period from 1977 to 1986, ranging from less than 2.5 MAF in 1977 to more than 64 MAF in 1983.

Other inflow sources to San Francisco Bay are: Alameda Creek, Napa River, Petaluma River, Coyote Creek, Guadalupe River, Walnut Creek, San Lorenzo Creek, and Sonoma Creek. These tributaries each have an average annual inflow of less than 200 cubic feet per second with peak flows considerably higher.

North Delta Region

The north Delta, part of the Sacramento–San Joaquin Delta, includes channel systems south of Sacramento, north of the San Joaquin River, east of Rio Vista, and west of Thornton, as shown in Figure 1–1. The small communities of Courtland, Locke, Walnut Grove, Terminous, and Isleton provide agricultural, recreational, and other services. Local roads and State Highways 12 and 160 provide access to the area.

Vegetation in the Delta can be classified using the following habitat groups:

- Riparian–consists of a rather narrow band of vegetation occurring along waterways.
- Upland–represented by open areas, fallow fields, and grazing lands with vegetation consisting of natural grasses and herbs with few or no trees.
- Agricultural–includes cultivated row crops such as asparagus and sugar beets, field crops such as corn and safflower, and pear orchards.
- Urban–consists of residential and commercial areas. It is restricted to species tolerant of man and his machines.

The north Delta, until reclaimed by levees in the late 1800s and early 1900s, was a tidal marsh with meandering channels separated by low–lying islands. Area–wide flooding was an annual event and was part of the natural ecology of the area.

Now, federal flood control levees and bypass systems protect the Delta from flooding from its major tributaries when they initially enter the Delta, with the exception of the Cosumnes River/Dry Creek/Mokelumne River system. This makes the north Delta highly vulnerable to flooding.

The northern portion of the Delta has many scenic rivers and channels popular with boaters and anglers. Many of the levees defining these channels are heavily overgrown with vegetation to the extent that even some of the man-made levees appear to be untouched. There are several significant biological resource areas in this area. These areas consist of the Delta Meadows, Mokelumne/Cosumnes River complex, Beach Lake, and Stone Lakes (Figure 4–1).

Delta Meadows. The Delta Meadows area along Snodgrass Slough, appears much the same way it did 100 years ago and has especially heavy recreational use during spring and summer. It is comprised of islands that are several feet higher than the average level of Delta land and are surrounded by several interlocking waterways. Flood control levees buffer the entire project area. The levees and their waterside berms support lush vegetation which screens and protects the scenic and natural environment of the area.

Cosumnes/Mokelumne River Confluence. One of the few areas of the Delta that remains nearly as it was before reclamation efforts began in the last century is the Cosumnes/Mokelumne confluence area just north of Thornton. The Nature Conservancy has established the 1400–acre Cosumnes River Preserve at this location in an effort to preserve an unleveed riparian forest and wetlands ecosystem with the full array of naturally occurring biological diversity. The Beach Lake area just south of Freeport and north of the Stone Lake Basin is a privately-owned preserve open to the public for an annual fee. Hunting, fishing, camping and wildlife viewing occur in this area. The owners emphasize maintenance of maximum wildlife habitat, even with successful farming.

Stone Lakes. The Stone Lakes Basin is one of the last remaining natural freshwater lake habitats in the California Central Valley, with its complex interrelated water, marsh, and grassland ecosystem. It provides food and cover for one of the most unique and diverse populations of birds, fish, and animal life in the state. The basin contains the largest collection of bird species in the Central Valley, with some 100 different types identified. The basin serves as a major component of the international Pacific flyway by providing a seasonal home for many species of migratory waterfowl.

The U.S. Department of Agriculture Soil Conservation Service identifies four major soil association groups in the north Delta. These are:

- Poorly drained organic and mineral soils of the deltas;
- Deep, somewhat poorly drained soils of natural river levees and alluvial fans;
- Poorly drained clay and clay loam soils of basins and basin rims; and
- Shallow to moderately deep, somewhat excessively to poorly drained soils of the terraces.

Agriculture is the predominant land use in the north Delta. Agriculture has historically been the basis for most of the activity that occurs in the Delta and the Delta islands and tracts were originally reclaimed from swampland for

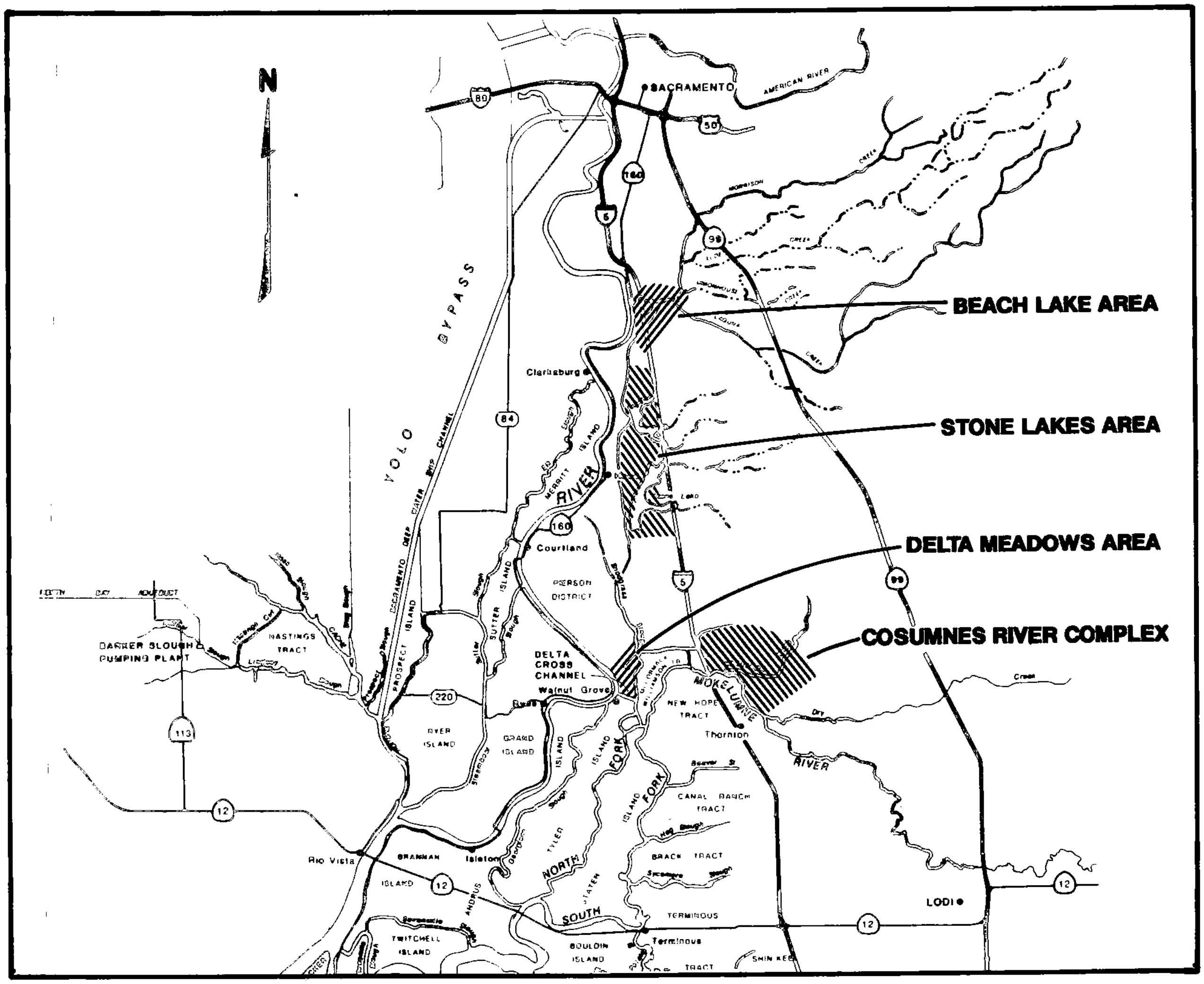


Figure 4–1. Significant Biological Resource Areas, North Delta Study Area

agricultural use. Despite the many changes that have taken place in and around the Delta area over the last 100 years, agriculture continues to maintain a strong influence over the lifestyles of the area residents.

Recreation

Although the north Delta environment has been extensively altered over the past 125 years by reclamation and development, natural and aesthetic values remain that make it a valuable and unique recreational asset. Waterfowl and wildlife are still abundant, sport fishing is still popular, and vegetation lining the channels and islands are still attractive. As a result, the miles of channels and sloughs that interlace the area attract a diverse and growing number of people seeking recreation.

Recreation has been a major concern in establishing State Water Project facilities. The basis for developing recreation at these facilities is contained in the Davis–Dolwig Act (Water Code Sections 11900–11925), adopted by the Legislature in 1961 after public hearings and discussions. The Davis–Dolwig Act declares that recreation and the enhancement of fish and wildlife resources are among the purposes of State water projects. The Act provides for the Department to allocate reimbursable costs of any SWP facility to recreation or fish and wildlife enhancement purposes. It further provides that land acquisition for recreation and fish and wildlife enhancement be planned and initiated as a part of the acquisition program for other project purposes. The Act recognizes that since the Department plans and acquires land for all other aspects of State water projects, the Department should have the responsibility for land acquisition for recreation and fish and wildlife as well.

With its unique and numerous recreational opportunities, the north Delta will continue to support large numbers of recreationists. Motor boating and fishing are the leading activities. The extensive riparian vegetation of the north Delta area is conducive to sightseeing, bird watching, and relaxing. Overnight camping, picnicking, swimming, and water-skiing, are enjoyed by many people. Photography, bicycling, hunting, and sailing are participated in less frequently.

The north Delta has many unique habitats worth protecting and enhancing. Habitat critical not only for wildlife, but also of considerable scenic value, presently protected or proposed for protection include:

- Stone Lakes Wildlife Refuge
- Cosumnes River Preserve
- Delta Meadows
- Snodgrass Slough
- Lost Slough
- Numerous channel islands and heavily vegetated berms

The proposed setback levee feature of the NDP can complement these sensitive areas. The setback levees will include water side berms to support the growth of riparian vegetation. The berms will also help as a buffer between recreational use in the waterways and private land use on the landward side of the levees. This will decrease trespassing on private lands. Controlled public access to portions of the levees can increase the recreation potential of the north Delta. Low impact recreation use combined with access restrictions, will ease some of the problems of limited land access and add wetland and riparian habitat to complement existing sensitive areas. Access restrictions will be coordinated with county,state, and federal agencies.

The north Delta has numerous commercial recreation facilities which are shown in Table 4-1 and Figure 4-2. These facilities provide rentals, services, camping, guest docks, fuel, supplies and food. Any recreation facilities provided with the NDP will complement rater than compete with existing facilities.

Cultural Resources

The Indians who lived in the north Delta area at the time of European contact are known as the Plains Miwok and-North Valley Yokuts.

The first contact with Europeans was made by Spanish expeditions in the first decade of the 19th century. Many of the Indians were drawn into the missions. This, coupled with the effects of European diseases and the onslaught of settlers after the 1849 gold rush, effectively destroyed the aboriginal way of life before much ethnographic information could be obtained.

Table 4-1. Commercial Recreation Facilities, North Delta

1. Courtland Docks	17. Tunnel Trailer Park	33. Korth's Pirates Lair Marina
2. Morgan's Landing	18. Sids Holiday Harbor	34. Moores Riverboat
3. Steamboat Landing	19. Snug Harbor	35. Willow Berm Boat Harbor
4. Steamboaters Resort	20. Hidden Harbor	36. Lighthouse Resort
5. Islands Marina	21. Vieira's Resort	37. Rancho Marina
6. Golden Gate Island Resort	22. Cliff House	38. Sycamore Park
7. The Boathouse	23. Ernie's	39. Perry's Boat Harbor
8. Walnut Grove Merchants Dock	24. Riverside Inn & Marina	40. B&W Resort Marina
		41. Tower Park Marina
9. Deckhands	25. Ox Bow Marina	42. Camp - A - Float
10. Delta Country Houseboats	26. The Spot	43. Herman & Helen's
11. Walnut Grove Marina	27. Owl Harbor	44. Uncle Bobbie's
12. New Hope Landing	28. Bruno's Island	45. King Islands Marina
13. Wimpy's Marina	29. Blue Heron Harbor	46. King Island Houseboats
14. Giusti's	30. Spindrift Marina	47. Holiday Flotels
15. Ryde Hotel	31. Andreas Cove	48. King Island Resort
16. Ko — Ket Resort	32. Happy Harbor	49. Paradise Point Marina

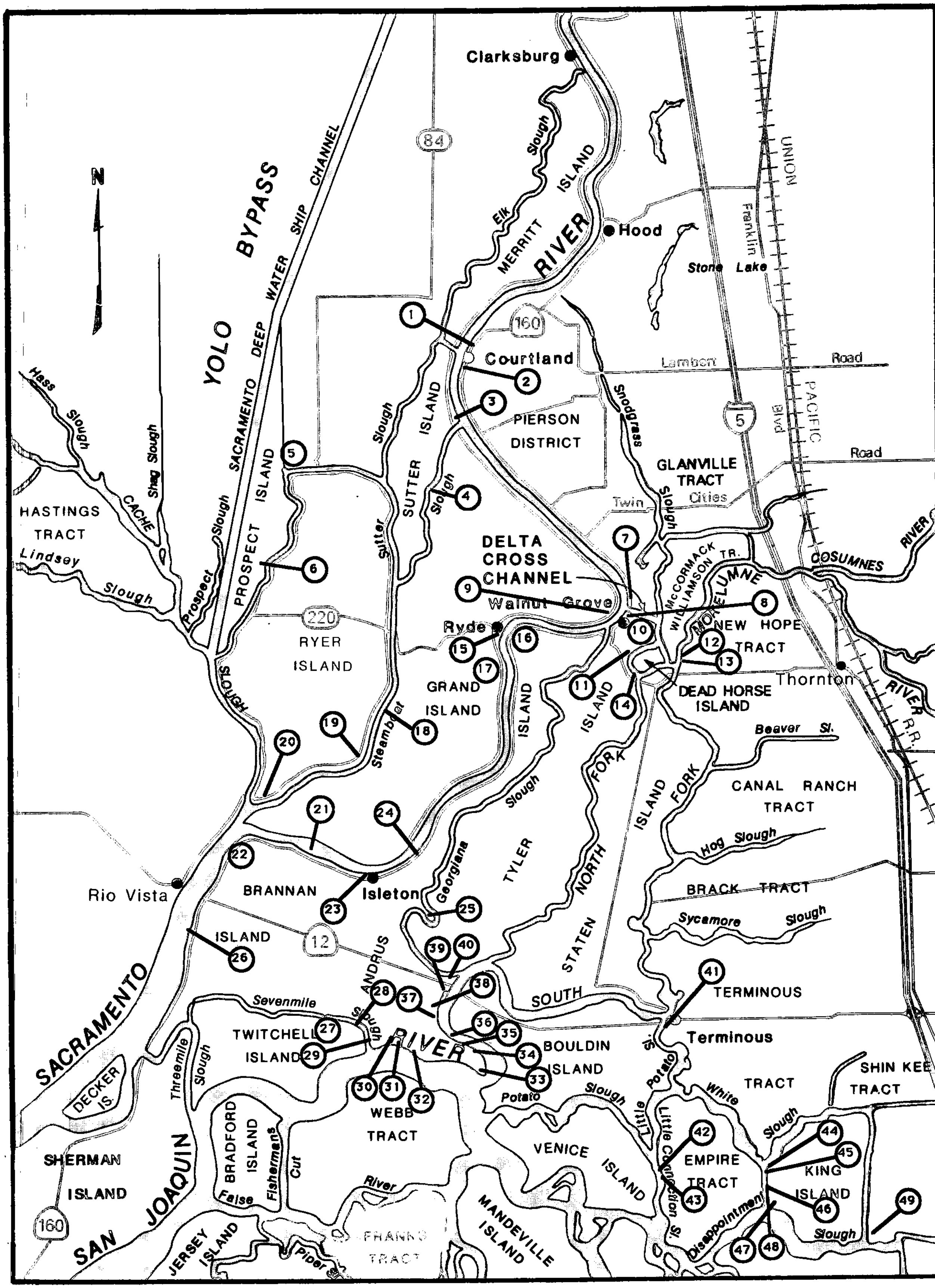


Figure 4-2. Commercial Recreation Facilities

A Class I archeological survey, consisting of a records search of previous surveys in the area, was conducted. One prehistoric archeological site and no historic sites were identified in the study area. This prehistoric site is mostly destroyed by farming activities (CSUS, 1989).

A Class II sample survey is in process by USBR archeology staff to determine the resources present in the study area that may be affected by the project. As part of the Class II survey, records of the sites identified in the Class I survey will be identified in an effort to determine the relationship between sites and landforms.

It has been established that areas of higher relief, those presently above sea level, have a high probability for the presence of prehistoric sites. Areas that prior to reclamation were uninhabitable tidal marsh are defined and may be excluded from further surveys.

Research of historic documents indicates that the first canals and levees were built in the 1850s. The records indicate that most of the area was in agricultural use by the late 1800s. Further historic research and field investigations are part of the Class II sample survey.

Findings of the Class II sample survey will help determine whether, and where, a Class III intensive survey is needed.

Fish and Related Habitat

Several species of anadromous and resident fish found in the Delta are also present in north Delta channels. The principal species are Chinook salmon, striped bass, steelhead, American shad, sturgeon, catfish, sunfish, and many native non-game species. The Delta fisheries are affected by the dissolved oxygen, water quality, and temperature in the channels.

These and other biological resources are discussed in Chapter 5.

Wildlife and Related Habitat

Most of the land on the islands in the north Delta consists of irrigated agriculture. The natural vegetation on the river banks is periodically modified in most places due to construction and maintenance of levees. Habitat or cover types in the north Delta are agriculture, forest, riparian-forest, riparian scrub-shrub, emergent freshwater marsh, and heavily shaded riverine aquatic.

The California Natural Diversity Data Base (CNDDB) classifies the emergent freshwater marsh as part of the Coastal and Freshwater Marsh plant community. The CNDDB has assigned this community one of its highest-priority classifications because agricultural and urban development has destroyed more than 90 percent of the original acreage of this community in the Central Valley. The CNDDB classifies the forest and riparian forest as Great Valley Oak Riparian Forest. The CNDDB has also assigned this community one of its highest priority classifications because nearly 90 percent of the acreage of this community has been destroyed and only 2.5 percent of the remaining habitat is in an apparently unaltered condition.

The heavily-shaded riverine aquatic habitat is an important habitat in the north Delta. It occurs where substantial woody vegetation overhangs a slough or river with continuously or periodically moving water.

Rare, Threatened, and Endangered Species

Rare, threatened, and endangered plant and animal species which may occur in the project area are shown in Table 4–2. The table also lists species which are candidates for listing as rare, threatened, or endangered by the U.S. Fish and Wildlife Service (USFWS) and the Department of Fish and Game (DFG).

Field surveys for rare, threatened, and endangered species were done in 1987, 1988, and 1989. The surveys are discussed in more detail in Appendix D.

Plants. Twenty–two Suisun Marsh aster plants were found in Little Potato and Little Connection sloughs and Burns Reach of the San Joaquin River either growing on in-stream islands or above rock revetment on the water side of levees. Nine populations of Mason's lilaeopsis were found in the project area, growing mainly on eroded mudbanks. The greatest density occurred on islands in Little Potato Slough. All other populations were isolated patches intermixed with other mudbank species..

California hibiscus was found at 10 locations scattered throughout the project area. The greatest concentration of California hibiscus was found in the Snodgrass Slough area. Individual plants were found in other locations.

Twelve populations of Delta tule pea were found; nine in Snodgrass Slough on tule islands.

Table 4–2
Rare, Threatened, and Endangered Species Potentially Occurring in the North Delta Project Area

Common Name	Scientific Name	Status*	Distribution	Habitat
		PLANTS		
Suisun Marsh aster	*Aster chilensis lentus*	C2	San Pablo Bay, Suisun Marsh, Delta	Dense vegetation, stabilized substrate
Antioch Dunes evening primrose	*Oenothera deltoides*	SE,FE	Delta	Sand dunes
Sanford's arrowhead	*Sagittaria sanfordii*	C2	Butte, Fresno, Sacramento, and Del Norte counties	Tule islands
Mason's lilaeopsis	*Lilaeopsis masonii*	C2, SR	Delta	Mudbanks
California hibiscus	*Hibiscus californicus*	C2	Delta & Central Valley up to Butte County	Freshwater marsh
Delta tule pea	*Lathyrus jepsonii jepsonii*	C2	Delta	Freshwater marsh
		ANIMALS		
Aleutian Canada goose	*Branta canadensis leucophareia*	FE	Western Delta, Modesto	Fresh and salt water marshes and waterways
Greater sandhill crane	*Grus canadensis tabida*	ST	Central Valley	Fresh water marsh, riparian areas, corn fields, near trees for nesting
California black rail	*Laterallus jamaicensis coturniculus*	C2, ST	Coast from Marin County to north Mexico; inland marshes	Fresh and salt water marshes
Tricolored blackbird	*Agelaius tricolor*	C2	Central Valley & Sierra Nevada foothills	Marshes, flooded lands, margins of ponds, grassy fields
Swainson's hawk	*Buteo swainsoni*	ST	Lower Sacramento and San Joaquin valleys; Klamath Basin; Siskiyou County. Winters in South America	Grasslands, irrigated pastures, and open fields near trees for nesting
Giant garter snake	*Thamnophis couchi gigas*	C2, ST	Fresno County north through the Central Valley; east Delta	Freshwater marsh, riparian areas, rice fields, canals
Western pond turtle	*Clemmys marmorata*	C2	Throughout California west of Cascade–Sierra crest	Ponds and waterways lined with emergent vegetation

(Continued on next page)

Table 4–2 (Continued)
Rare, Threatened, and Endangered Species Potentially Occurring in the North Delta Project Area

Common Name	Scientific Name	Status*	Distribution	Habitat
		ANIMALS (continued)		
California tiger salamander	*Ambystoma tigrinum californiense*	C2	Sonoma to Santa Barbara counties	Reservoirs, ponds, pools, lakes, and slow–flowing streams in grasslands and open woodlands
California red–legged frog	*Rana aurora draytoni*	C2	Coast, Transverse, Cascade, and Sierra Nevada ranges	Quiet, permanent water in woods, forest clearings, riparian areas, grasslands
Valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*	FT	Lower Sacramento Valley north to Red Bluff	Elderberry bushes in riparian areas
Sacramento anthicid beetle	*Anthicus sacramento*	C2	Yolo, Solano, Butte, & Sacramento counties	Sand dunes near rivers
Delta smelt	*Hypomesus transpacificus*	C1, SC	Suisun & San Pablo Bays in early fall; spawns in channels & dead–end sloughs, December through April	Salinities usually less than 2 parts per thousand
Sacramento splittail	*Pogonichthys macrolepidotus*	(C2)	Suisun Bay from February—April; spawns in upstream deadend sloughs Jan–July	Slower currents; tolerates brackish water
Sacramento perch	*Archoplites interruptus*	(C2)	Sacramento–San Joaquin Delta; Russian River; Scattered lakes & reservoirs	Needs beds of rooted & emergent aquatic vegetation; tolerates alkaline water
Chinook salmon (winter–run)	*Oncorhynchus tshawytscha*	FT, SE	Sacramento River system	Cool fresh water with access to ocean

*Status: FT = federal threatened; FE = federal endangered; C1 = federal candidate with sufficient data to support federal listing; C2 = federal candidate currently without sufficient data to support federal listing; ST = State threatened; SE = State endangered; SR = State rare; SC = State candidate for protected status; (C2) = Currently being recommended by the Sacramento Endangered Species Office that the species be proposed as a C2.

Sanford's arrowhead was found at two locations in the project area. Ten populations were found on a point bar in Steamboat Slough. The other location, North Fork Mokelumne River, was estimated to contain thousands of individuals.No Antioch Dunes evening primrose was found.

Animals. Several active Swainson's hawk nests were found in trees along Snodgrass Slough, Steamboat Slough, and the Mokelumne River in the study area. A pair of Swainson's hawks was also seen flying over the Mokelumne River adjacent to agricultural fields. While nesting habitat is absent from most of the South Fork Mokelumne and North Fork Mokelumne, the project area does contain a significant portion of the riparian woodland remaining in the Delta.

Two black rail responses were heard at one location in Little Potato Slough at its confluence with White Slough. The habitat along the southern end of the island is dominated by emergent bulrush and cattails in the tidal zone and by shrub and tree willow, cottonwood, and dogwood (*Salix* spp., *Populus fremontii*, and *Cornus stolonifera*) in upland areas. Suitable black rail habitat throughout the remainder of the project area is limited. The few areas of marsh vegetation are either growing from inundated substrates or are dominated by willows.

No tricolored blackbird individuals or nesting colonies were observed in the project area. Tricolored blackbirds can shift their nesting locations from one year to the next. The nearest known previous nesting colony is about 8 miles east of the project area. Habitat which may be suitable for nesting is found in cattail/tule stands along the watercourses and in scattered areas of mustard bordering agricultural fields. With the possible exception of Snodgrass Slough and Lost Slough, the amount of emergent marsh vegetation in the project area is probably not large enough for winter roosting.

Only one giant garter snake was observed during surveys. The snake, a large pregnant female, was found west of Snodgrass Slough about 0.75 miles NNE of Locke. However, a suitable habitat consisting of marsh and streambed riparian vegetation is widespread in the project area. Areas of suitable habitat include vegetated levees, vegetated islands and mid-channel berms, and vegetated irrigation canals and drains within agricultural lands. Virtually all islands and channels in the study area contain some suitable habitat. There are records of giant garter snakes from similar habitats in the Delta. Because this snake is very wary and difficult to census, it may occur in the project area despite the lack of sightings.

Suitable habitat for western pond turtles occurs along all watercourses in the project area. Several large, adult western pond turtles were observed during field surveys in Lost Slough, Snodgrass Slough, and the South Fork Mokelumne River. Since no small turtles were observed, it is not known whether a viable breeding population exists in these areas.

No California tiger salamanders or California red-legged frogs were found nor does suitable habitat exist in the project area. These species require quiet, still water for breeding. The major waterways in the project area are too deep, swift, and subject to frequent inundation. Many of the irrigation ditches are kept clear of aquatic vegetation. The surrounding lands are intensively cultivated.

No field surveys were conducted for winter run Chinook salmon, Sacramento perch, Delta smelt, or Sacramento splittail. The winter run Chinook salmon has recently been listed as an endangered species by the State, and has a federal emergency listing as threatened.

Little is known of Delta smelt occurrence in the project area. Suitable habitat may be present, but due to the large population decline, this habitat may not be occupied. Delta smelt were not encountered during DFG electrofish studies in the Mokelumne River area in the early 1980s.

DFG electrofishing studies in the Mokelumne River and South Fork Mokelumne River in the early 1980s found no Sacramento perch; the species has not been seen in the Delta since the 1970s. It is unlikely that the species occurs in the project area.

DFG electrofishing surveys in 1981 found over 20 splittail in the Mokelumne River near the Interstate 5 bridge, indicating the the species probably spawns in that portion of the river. A few individuals were also found at scattered locations in the South Fork Mokelumne River and Snodgrass Slough.

No specific surveys for the Sacramento anthicid beetle and the Antioch dune beetle were undertaken; rather, during other survey efforts, observers conscious of habitat requirements watched for suitable habitat (riverine dunes). The Antioch dune beetle is believed to be restricted to two locations: the west end of Grand Island, Sacramento County; and Sandy Beach County Park, near Rio Vista, Solano County. Both locations are also reported to support populations of the Sacramento anthicid beetle. The closest known population, at Grand Island, is about 9 miles west of the project area.

Analysis of aerial photographs and recent soil mapping identified two to three acres of remnant dune habitat north of Lambert Road, between Snodgrass Slough and the Southern Pacific Railroad grade. No other suitable habitat was identified during survey efforts.

Due to the specificity of the valley elderberry beetle for the elderberry and the large proportion of the beetle's lifespan spent within it, the primary survey method is identification of elderberry plants. If plants are located, secondary survey methods include canvassing of plants for adult emergency holes. Surveys were conducted by automobile, boat, and on foot to cover areas potentially impacted by the project alternatives.

Elderberry was widely distributed and relatively dense along both sides of the Mokelumne River between Interstate 5 and New Hope Landing, where it was a common component of the mixed riparian woodland which borders this reach. Plants of all age classes were represented. Elderberry is common to both sides of the levee along the Mokelumne River upstream of I-5 to Dry Creek. One plant exhibited a single emergence hole about 1–2 years old. Due to this evidence, and the proximity of these plants to other reported occurrences along the Cosumnes River, elderberry in this reach should be considered potential and/or actual habitat.

Only a few widely-scattered elderberry plants were located along the South Fork of the Mokelumne River between New Hope Landing and Terminous. No riparian woodland remains in this reach except immediately south of the Walnut Grove Road crossing. A single elderberry plant was identified on the east side of Tyler Island about 1.5 miles downstream from Dead Horse Island. Due to its proximity to other reported occurrences, this plant should be considered potential habitat.

Other areas currently supporting elderberry include the banks of Snodgrass Slough, Lost Slough, and Dead Horse Cut, the perimeter of Dead Horse Island, the Staten Island levee north of Walnut Grove Road, and scattered locations along Highway 160 between Snodgrass Slough and Hood.

Delta Region

The Delta has legal boundaries established in California Water Code Section 12220 and shown on Figure 4-3. The Delta is generally bordered by the cities of Sacramento, Stockton, Tracy, and Pittsburg. The 738,000 acres in the Delta are part of the largest estuary in California. The former wetlands have been reclaimed into more than 60 islands and tracts, largely devoted to farming (about 520,000 acres), which produce an average gross income of about $375 million. The Delta is interlaced with about 700 miles of waterways. The network of levees totals about 1,100 miles and protects the islands and tracts, almost all of which lie below sea level.

Protection of certain islands from flooding is particularly important because of the threat to life and property, the presence of utilities and highways, and water quality degradation from the sudden intrusion of brackish water from the Bay. Long-term water supply problems could occur should a Delta levee break, particularly if an island were allowed to remain flooded and no remedial action were taken. Evaporation from a flooded island exceeds the consumptive use of an equivalent area of irrigated farmland by about one or two feet per year. This increase would require the State and federal water projects to release more upstream water from storage to repel salinity intrusion. Permanent flooding of certain islands in the western Delta (where brackish water and fresh water meet) could increase the upstream movement of ocean salts, requiring the projects to provide more outflow to repel the salts and maintain water quality in the Delta and at the pumps.

Although no major cities are entirely within the Delta, it does include a portion of Stockton, Sacramento, West Sacramento; the small cities of Antioch, Brentwood, Isleton, Pittsburg, and Tracy; plus about 14 unincorporated towns and villages. The population in the legal Delta is about 200,000, most of it in upland areas on the eastern and western fringes. The Stockton area, on the east, and the Antioch-Pittsburg area, on the west, have undergone steady industrialization and urbanization. Most Delta islands are sparsely populated; some, however, including Byron Tract and Bethel Island have large urban communities.

Several municipal and industrial water users in the western Delta maintain dual supply systems for fresh water—off-shore diversion and the Contra Costa Canal. Offshore water is used when the quality is adequate for the intended use, and Contra Costa Canal supplies are used when offshore quality is degraded below acceptable limits due to low Delta outflows. The Contra Costa Canal is the sole source of municipal water for other Contra Costa Water District customers.

Delta agricultural water users divert directly from the channels, using more than 1,800 unscreened pumps and siphons, which vary from 4 to 30 inches in diameter, and with flow rates of 4 to about 200 cfs. Total diversions vary between 2,500 and 5,000 cfs during April through August, with maximum rates in July.

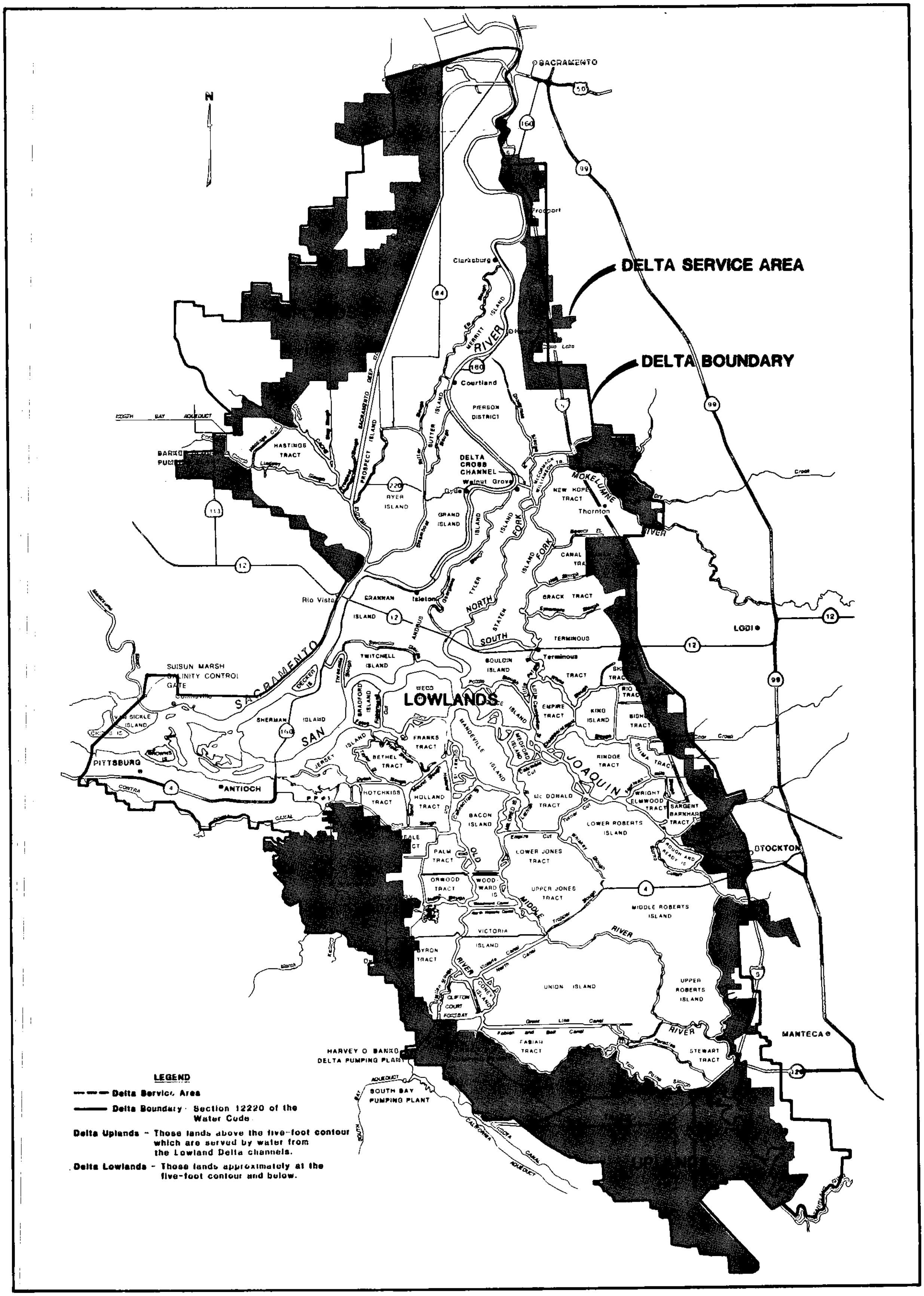


Figure 4-3. Statutory Delta Service Area

The climate of the Delta area is Mediterranean with warm, rainless summers and cool, moist winters. The annual rainfall varies from about 18 inches in the easternand central parts to about 12 inches in the southern part. Ocean winds enter the Delta through the Carquinez Strait and are very strong at times in the western Delta.

The Delta is basically a fresh-water environment, which serves as a migratory route and nursery area for chinook salmon, striped bass, sturgeon, American shad, and steelhead trout. Numerous resident warmwater fish include catfish, sunfish, and minnows. White catfish are heavily fished by anglers casting from the banks.

The Delta also supports many animals and birds in the riparian and upland habitats. The Delta contributes about 20 percent of the pheasant population taken by California hunters each year. The area also serves as a feeding and resting area for millions of ducks, geese, swans, and other migrant waterfowl.

Ten listed rare, threatened, or endangered vertebrate species are known to live in the Delta, but none is confined exclusively to that area. Six are birds—the bald eagle, American peregrine falcon, Swainson's hawk, California black rail, Aleutian Canada goose, and California yellow-billed cuckoo. Two are mammals—the saltmarsh harvest mouse and the San Joaquin kit fox. One—the giant garter snake—is a reptile, and one—the winter run Chinook salmon—is a fish. There are three endangered or threatened invertebrate species in the Delta: the Valley elderberry longhorn beetle, Lange's metalmark butterfly, and the Delta green ground beetle. Twelve rare or endangered plant species, most of which are associated with fresh water marshes, can also be found in the Delta.

A complete list of Delta plant and animal species is contained in *Sacramento/San Joaquin Delta Wildlife Habitat Protection and Restoration Plan*, California DFG and U. S. Fish and Wildlife Service, December 1980.

The Delta's abundant water, fish, wildlife, cultural, and historical resources make it a major recreation area. There are about 20 public and more than 100 commercial recreation facilities in the Delta. Demand for and use of these facilities continue to grow.

Suisun Marsh

Suisun Marsh, one of the few major marshes remaining in California, is at the northern edge of Suisun Bay, just west of the confluence of the Sacramento and San Joaquin rivers and south of the city of Fairfield. The primary managed area contains 58,600 acres of marsh, managed wetlands, and adjacent grasslands, plus 29,500 acres of bays and waterways. An additional 27,900 acres of varying land types acts as a buffer zone.

Most of the managed wetlands are enclosed within levee systems, and about 70 percent are privately owned by more than 150 duck clubs. The California DFG owns and manages 14,000 acres. Another 1,400 acres on the channel islands is owned by the federal government.

Waterfowl are the marsh's major wildlife. Ducks, geese, swans, and other migrant waterfowl use the marsh as a feeding and resting area. As many as 25 percent of California's wintering waterfowl inhabit the marsh in dry winters. The marsh also supports 45 species of mammals, 15 species of reptiles and amphibians, and 230 species of birds. Two endangered species, the salt marsh harvest mouse and the California clapper rail; one rare species, the California black rail; and one species being proposed for protection, the Suisun song sparrow, probably occur in the Marsh.

Most fish in marsh channels are striped bass. Other anadromous species sometimes found in the marsh include Chinook salmon, sturgeon, American shad, and steelhead trout. The marsh is also an important nursery area for striped bass. Catfish also support a sport fishery.

Waterfowl are attracted to the marsh by the water and the abundance of natural food plants, most valuable of which are alkali bulrush, fat hen, and brass buttons. Growth of such plants depends on proper soil salinity, which is affected by salinity of applied water. Freshwater flows from the Delta into Suisun Bay and Marsh channels from Octo-

Migrating Birds

ber through May affect marsh salinities and waterfowl food production.

The Suisun Marsh is protected by several standards, agreements, and facilities. Among them is Water Rights Decision 1485, which requires the SWP and CVP to mitigate their impacts on the marsh by meeting specific standards for the Sacramento River at Collinsville and seven other stations in the marsh. As allowed by Decision 1485, facilities have been constructed to provide water from internal channels to certain wetland areas. In addition, DWR, Reclamation, the DFG, and the Suisun Resource Conservation District signed a Suisun Marsh Preservation Agreement in 1987 to assure that a dependable water supply will be maintained in the marsh to produce duck food and to preserve other habitat.

San Francisco Bay Area

San Francisco Bay—including Suisun, San Pablo, Central, and South bays—extends about 85 miles from the east end of Chipps Island, near the city of Antioch westward and southward to the mouth of Coyote Creek, near the city of San Jose (Figure 4–4). The Golden Gate connects San Francisco Bay with the Pacific Ocean.

The surface area of San Francisco Bay is about 400 square miles at mean tide, about a 40 percent reduction from its original size. The reduction is due to fill. Most of the Bay's shoreline has a flat slope, which causes the intertidal zone to be relatively large. The volume of water in the bay changes by about 21 percent from mean higher–high tide to mean lower–low tide. The depth of the bay averages 20 feet overall.

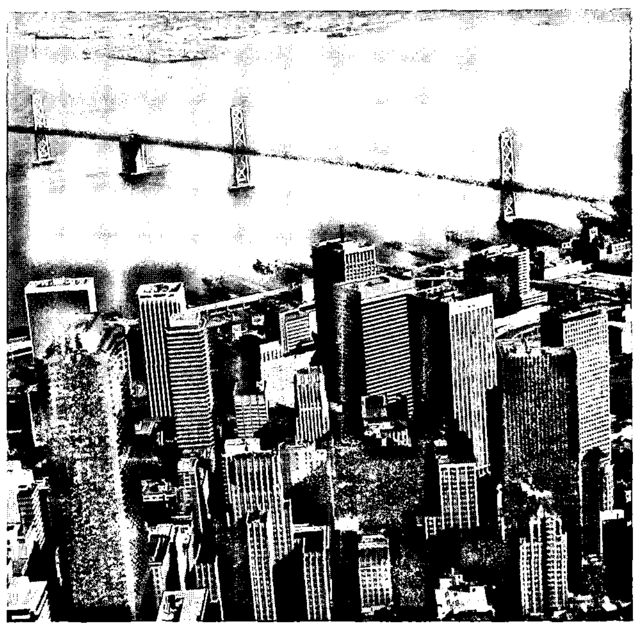
The principal source of fresh water in San Francisco Bay is outflow from the Delta. Delta outflows vary greatly according to month and hydrologic year type. Historic Delta outflow has dropped to zero during critically dry periods such as 1928 and 1934. Present summer Delta outflows are maintained by upstream reservoir releases. Although annual Delta outflow has averaged 24 MAF from 1977 to 1986, it has varied from less than 2.5 MAF in 1977 to more than 64 MAF in 1983.

Other significant sources of fresh–water inflow to San Francisco Bay are Alameda Creek, Napa River, Petaluma River, Coyote Creek, Guadalupe River, Walnut Creek, and Sonoma Creek. These tributaries make up a total average annual inflow of about 350 TAF. Streamflow is highly seasonal, with more than 90 percent of the annual runoff occurring during November through April. Many streams often have very little flow during mid– or late summer.

Nine counties surround the San Francisco Bay: Marin, San Francisco, San Mateo, Santa Clara, Alameda, Contra Costa, Solano, Napa, and Sonoma. In 1987 the Bay area became the fourth largest metropolitan area in the United States. The total 1988 population was about 5.8 million and is projected to reach 6.2 million by 1995 and 6.7 million by 2005.

Water requirements in the Bay area are met by 1) local surface and ground water supplies, and 2) imported surface water. The conveyance systems that bring the area the majority of its water are: Hetch Hetchy, South Bay, North Bay, Mokelumne, Petaluma, and Santa Rosa–Sonoma aqueducts; Contra Costa and Putah South canals; Cache Slough Conduit; and the San Felipe Project. More than 60 percent of the water is imported from Delta supplies.

The bays and surrounding lands support a wide variety of fish, migratory birds, and mammals. The anadromous species of fish include Chinook salmon, striped bass, sturgeon, American shad, and steelhead trout. Marine fish, found mainly in the lower bays, include flatfish, sharks, and surf perch. Shellfish in the San Francisco bays include mussels, oysters, clams, crabs, and shrimp. Seasonal vari



City of San Francisco

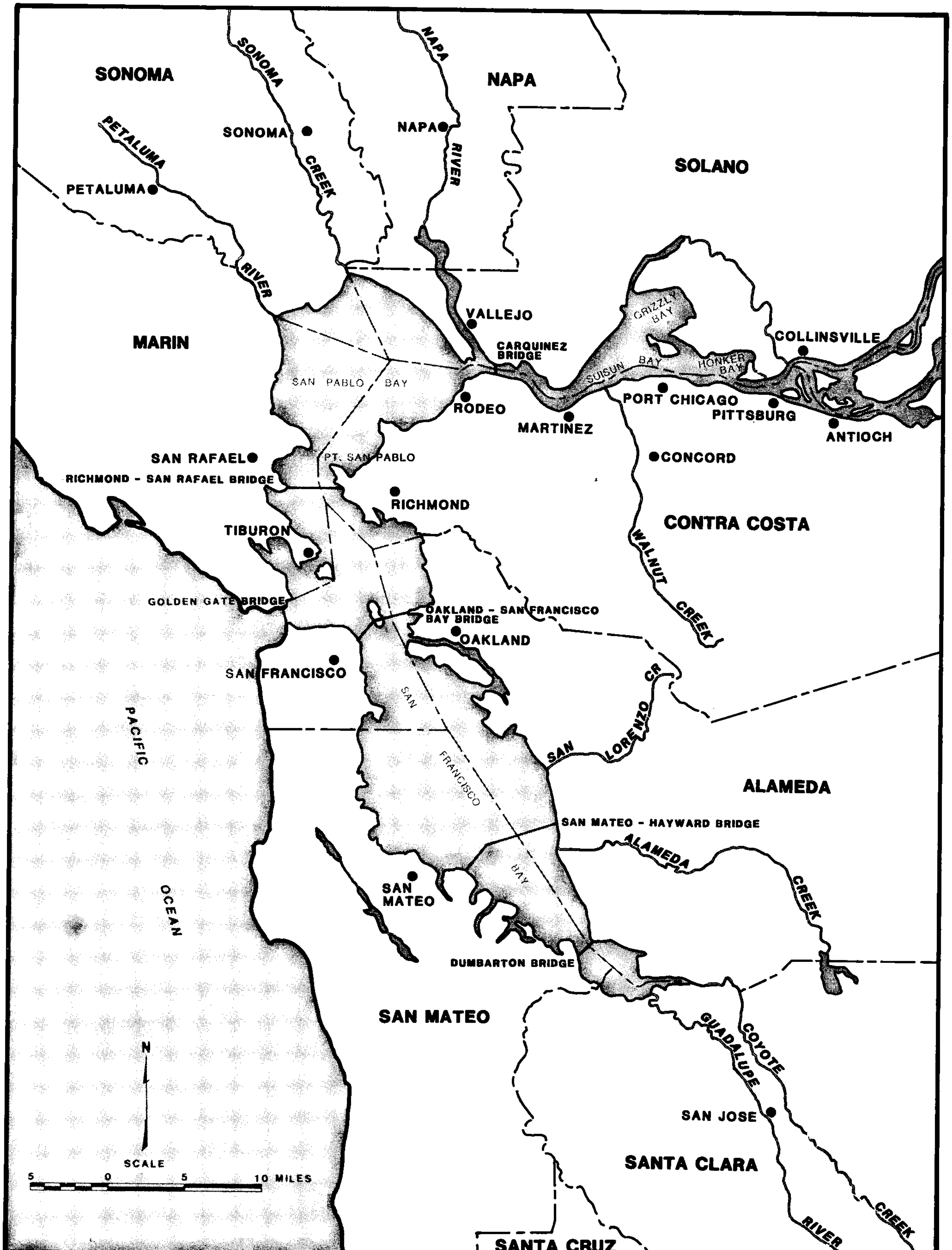


Figure 4–4. San Francisco Bay Complex

ations in salinity in the bays, due to varying Delta outflows, affect the seasonal distribution of fish and invertebrates.

Several rare and endangered animal species found in the area include the Alameda striped racer, salt marsh harvest mouse, San Francisco garter snake, California clapper rail, California black rail, and California yellow billed cuckoo.

Mild temperatures and brisk winds make San Francisco Bay one of the world's favorite recreational boating areas. More than 150,000 recreational boats were registered in the Bay Area in 1987. Other water-oriented recreation includes sight-seeing, picnicking, fishing, nature walking, and camping.

Sacramento Valley

The Sacramento Valley encompasses the drainage areas of California's largest river, the Sacramento. Valley lands comprise the western drainage of the Sierra Nevada and the Cascade Range, the eastern drainage of the Coast Ranges, and the valley floor (34 percent of the basin). The overall valley includes the McCloud and Pit rivers basins, the portion of Goose Lake Basin within California, and the American River and Putah Creek drainage. Other major river basins are those of the Feather, Yuba, and Bear rivers (which flow from the Sierra Nevada) and Cottonwood, Stony, and Cache creeks (which drain the Coast Ranges).

Ground water is pumped from 21 principal basins, most of which underlie the valley floor. The safe ground water yield is about 1.6 MAF per year, and the annual overdraft is about 140 TAF.

The 1985 population for the Sacramento Valley region exceeded 1.8 million. Urban areas include Sacramento, West Sacramento, Redding, Chico, Davis, Placerville, Woodland, Roseville, Yuba City, Auburn, Marysville, Oroville, Willows, Red Bluff, Quincy, Nevada City, and Alturas.

Agriculture (primarily irrigated) is the major economic activity in the Sacramento Valley and surrounding foothills. Industrial activity is closely allied with agriculture and, more recently, with national defense. Population growth has given rise to many service industries. Lumbering and timber industrial installations are centered in the Sierra Nevada, Cascade Range, Modoc Plateau, and a portion of the Coast Ranges. Plants that process logging and milling residues to form timber byproducts are located throughout the valley. Other industries are engaged in extraction or mining and production of natural gas, clay, limestone, sand, gravel, and other minerals.

Water resources in the valley have been developed extensively for a wide range of purposes. Water is also imported into the valley from the Truckee and Cosumnes rivers and from the Trinity River Division of the CVP. The first two importations are small, but the third is substantial.

The environment in the estuary is directly affected by industrial and agricultural growth in the Sacramento Valley and the accompanying reduction in both quantity and quality of water flowing into the Delta. Several species of anadromous fish, including the endangered winter-run Chinook salmon, migrate through the Delta to use Sacramento Valley streams for spawning.

Eight terrestrial habitat types are found within the Sacramento Valley, including coniferous forests, hardwood forests, chaparral and mountain brush, pinion and juniper, grass and forbs, desert shrubs, cultivated and pasture lands, and barren ground. Interspersed with the terrestrial habitats are four aquatic habitat types: the Delta, riparian, marshland, and open water. These habitats support hundreds of species of mammals, amphibians, reptiles, birds, and plants, including rare and endangered species.

For more information on plant and animal life in the Sacramento Valley, see the *Water Quality Control Plan Report for Basins 5A and 5B*, State Water Resources Control Board (1975).

San Joaquin Valley

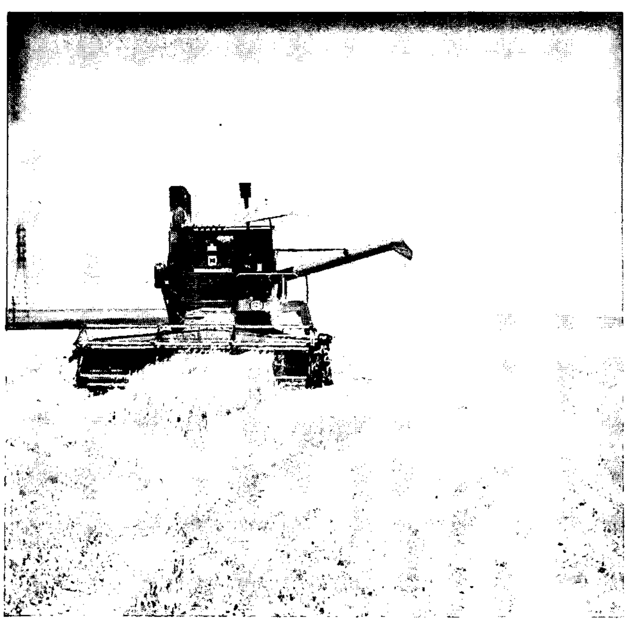
The San Joaquin Valley, the largest single block of irrigated land in California, comprises two hydrologic regions: the San Joaquin River and Tulare Lake. The San Joaquin River Basin, located just south of the Sacramento River basin, comprises the northern part of the San Joaquin Valley, whereas the Tulare Lake Basin, essentially a closed basin, comprises the southern part of the valley.

The San Joaquin River basin portion of the valley is drained by the San Joaquin River, which flows into the Delta and San Francisco Bay. Principal tributaries of the San Joaquin River include the Stanislaus, Tuolumne, Merced, Chowchilla, and Fresno rivers, all originating in the Sierra Nevada. In the Delta, the Cosumnes, Mokelumne, and Calaveras rivers—which also originate in the Sierra—become part of the San Joaquin River before it joins the Sacramento River.

These Sierra streams provide the northern part of the San Joaquin Valley with high-quality water and most of its surface water supplies. Most of this water is regulated by reservoirs and used on the east side of the valley, but some is diverted across the valley to the Bay area via the Mokelumne Aqueduct and the Hetch Hetchy Aqueduct. The streams flowing into the valley from the west are intermittent, often highly mineralized, and contribute little to water supplies.

The Tulare Lake Basin, at the southern half of the San Joaquin Valley, comprises the Kings, Kern, Tule, and Kaweah river basins. These four rivers drain westward from the southern Sierra Nevada and terminate in the Tulare Lake or Buena Vista Lake beds. Dams on each of these rivers provide flood control and water supply for ground water recharge and for urban and agricultural uses.

The valley's long growing season, mild and semi-arid climate, good soils, and available water provide conditions suitable for a wide variety of crops. Major crops include cotton, grapes, tomatoes, hay, sugar beets, and various orchard and vegetable crops. Agriculture and closely related industries provide the economic base that supports a large and growing population. The population in the valley grew from 1.7 million in 1970 to 2.5 million in 1985. Urban areas include Fresno, Bakersfield, Visalia, and Modesto.



Agriculture in the San Joaquin Valley

Water to the valley from the Sierra Nevada is limited and there is an annual overdraft of ground water. Imported water, generally ranging from 200 to 500 mg/l total dissolved solids, is used mainly on the west side. Water used on the east side is generally of better quality than that used on the west side and in the valley trough areas. In most parts of the valley, irrigation water is reused at least once, and water quality worsens progressively with each reuse.

Types of habitat in the San Joaquin Valley are similar to those of the Sacramento Valley. More information on plant and animal life in the San Joaquin Valley is contained in the *Water Quality Control Plan Report for Basins 5B, 5C, and 5D*, State Water Resources Control Board.

SWP Service Areas

The 30 long-term water supply contractors of the SWP are organized into six service areas: Feather River, North Bay, South Bay, Central Coast, San Joaquin Valley, and Southern California (Figure 4–5). These areas vary widely in size, location, climate, and population.

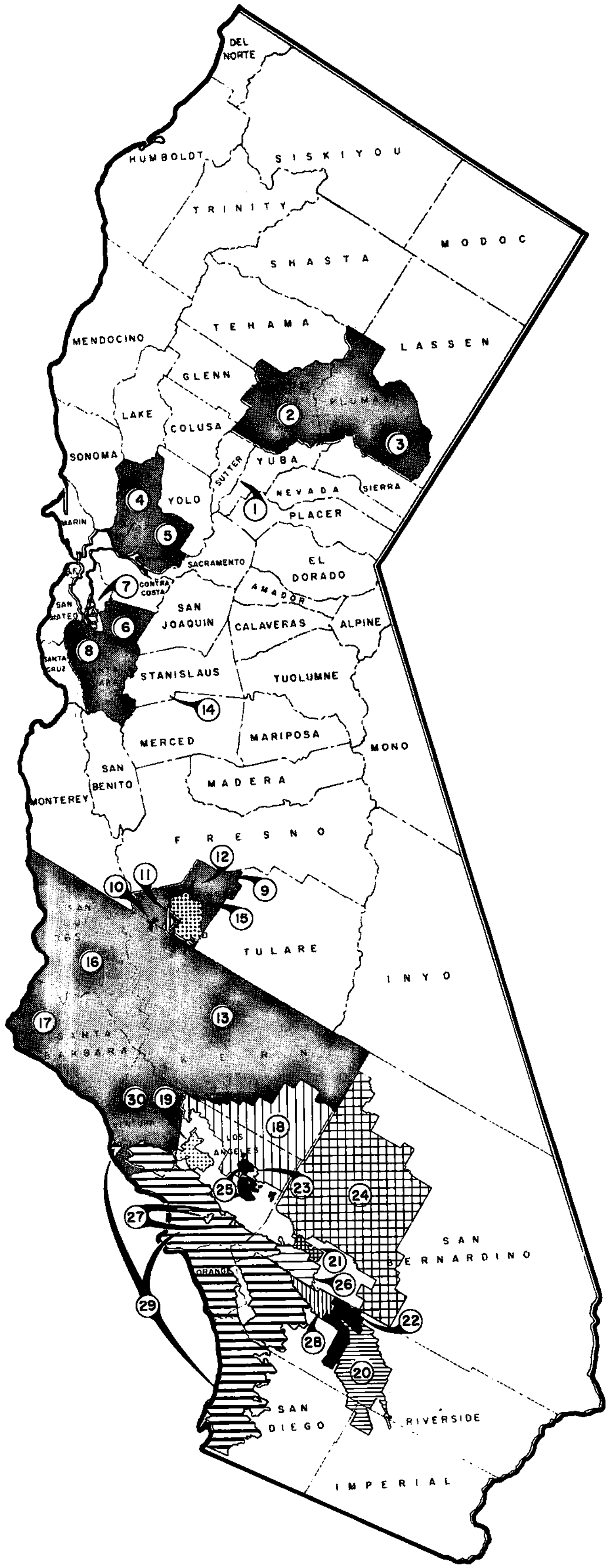
The Feather River service area has area-of-origin priorities for SWP supplies. The other service areas are described briefly in this section. Detailed environmental and socioeconomic profiles of these areas may be found in the *SWP Service Area Impact Study,* May 1985.

North Bay Service Area

The North Bay service area is located at the northern end of San Francisco Bay. Napa and Solano counties make up the total service area and encompass 1.1 million acres. About 64,000 acres were in urban use in 1980.

An estimated 95,000 people live in Napa County, primarily in the Napa Valley communities. The population of Solano County is about 303,500 and is distributed among seven cities and scattered rural areas. The California Department of Finance has projected that Solano County population will grow 10 percent between 1988 and 1990.

Napa County is well known for its production of wines and brandies. There is also a substantial livestock and dairy industry. Solano County agriculture centers on field crops, with substantial values of fruit and nut crops and a significant livestock industry. Heavy water-using industries include two meat packing companies and a cannery in



Location No.	Contracting Agency	Maximum Annual Entitlement (acre-feet)
	UPPER FEATHER AREA	
1	City of Yuba City	9,600
2	County of Butte	27,500
3	Plumas County Flood Control and Water Conservation District	2,700
	Subtotal	39,800
	NORTH BAY AREA	
4	Napa County Flood Control and Water Conservation District	25,000
5	Solano County Flood Control and Water Conservation District	42,000
	Subtotal	67,000
	SOUTH BAY AREA	
6	Alameda County Flood Control and Water Conservation District, Zone 7	46,000
7	Alameda County Water District	42,000
8	Santa Clara Valley Water District	100,000
	Subtotal	188,000
	SAN JOAQUIN VALLEY AREA	
9	County of Kings	4,000
10	Devil's Den Water District	12,700
11	Dudley Ridge Water District	57,700
12	Empire West Side Irrigation District	3,000
13	Kern County Water Agency	1,153,400
14	Oak Flat Water District	5,700
15	Tulare Lake Basin Water Storage District	118,500
	Subtotal	1,355,000
	CENTRAL COASTAL AREA	
16	San Luis Obispo County Flood Control and Water Conservation District	25,000
17	Santa Barbara County Flood Control and and Water Conservation District	45,486
	Subtotal	70,486
	SOUTHERN CALIFORNIA AREA	
18	Antelope Valley-East Kern Water Agency	138,400
19	Castaic Lake Water Agency	41,500
20	Coachella Valley Water District	23,100
21	Crestline-Lake Arrowhead Water Agency	5,800
22	Desert Water Agency	38,100
23	Littlerock Creek Irrigation District	2,300
24	Mojave Water Agency	50,800
25	Palmdale Water District	17,300
26	San Bernardino Valley Municipal Water District	102,600
27	San Gabriel Valley Municipal Water District	28,800
28	San Gorgonio Pass Water Agency	17,300
29	The Metropolitan Water District of Southern California	2,011,500
30	Ventura County Flood Control District	20,000
	Subtotal	2,497,500
	TOTAL STATE WATER PROJECT	4,217,786

Figure 4-5. SWP Service Areas and Contracting Agencies

Dixon, a refinery in Benicia, a brewery in Fairfield, and two food processors in Vacaville. Two major defense facilities are located in the region: Mare Island Naval Shipyard and Travis Air Force Base.Napa County's water supply comes from the North Bay Aqueduct, several small reservoirs, and a number of springs and wells.

Sources of water for Solano County include the North Bay Aqueduct, surface water from Lake Berryessa—the principal storage facility of the federal Solano Project— Lake Solano, and several small reservoir and stream projects, plus ground water, agricultural return flows, and reclaimed waste water.

North Bay Aqueduct water delivered to Napa County is used in the city of Napa and by exchange in American Canyon, Yountville, and Calistoga. Deliveries to Solano County supply municipal and industrial uses in five cities: Benicia, Fairfield, Suisun, Vacaville, and Vallejo.

A major restriction on the use of ground water, particularly for municipal and industrial needs, is the variable and uncertain quality in both counties. In Napa County, ground water quality is generally poor north of St. Helena and south of Napa. Because most of any additional demand for water in Napa County would be for municipal and industrial use, where both quality and quantity are crucial, ground water will probably continue to be used as a supplemental local source, mainly for agriculture. In any case, usable ground water storage capacity is restricted to the area between Napa and St. Helena, and the safe yield is currently overdrafted.

Solano County contains two major ground water basins—Putah Plain and Suisun-Fairfield Valley—and several smaller basins. Most ground water supplies are used for irrigation, although Vacaville, Rio Vista, and Dixon rely on ground water for domestic supplies.

Principal native plant communities include hardwood forest, chaparral, blue oak and digger pine forest, grassland, riparian habitat, and marshlands. The prairie grasslands are now mostly cultivated, but dense and varied riparian vegetation still exists along most rivers and streams. The marshes are mostly in the south-central portion of Solano County and the southern portion of Napa County. In addition to the principal plant communities, unique flora occur in vernal pools in the Jepson Prairie area of Solano County.

Game fish abound in the Sacramento River and in the salt and brackish water marshes on the borders of the two-counties. Migrating waterfowl use the marshes as stop-overs and winter habitat.

South Bay Service Area

The South Bay service area includes portions of Alameda and Santa Clara counties around the southern half of San Francisco Bay. Alameda County has some natural runoff from Alameda Creek, but only Santa Clara County has significant surface water supplies.

In this service area, ground water basins have been intensively developed for domestic, industrial, and irrigation uses and have been overdrawn, with resultant sea-water intrusion and land-subsidence problems. Extensive recharge programs using local and imported water supplies have allowed substantial recovery of the ground water basins. Water is imported from the Tuolumne River via the Hetch Hetchy Aqueduct, and from the Delta via the South Bay Aqueduct and the San Felipe Project.

Counties in the South Bay service area encompass 1,184,000 acres. About 305,000 acres were in urban use in 1980. The 1986 population was 1,638,000.

The South Bay is Northern California's leading business center. The economy of the area is diversified, with manufacturing, commerce, services, and government sectors employing significant numbers of people.

Historically, Santa Clara County's economy was dominated by agriculture. However, the rapid urban development of the county has displaced much of the farming, which is now carried out in the less populated southern part of the county.

Some rare or endangered species exist in the marshes in and around San Francisco Bay. Their habitat has been significantly reduced by bay filling and diking. Undisturbed areas are now protected by various State, federal, local, and private interests.

Central Coast Service Area

The Central Coast service area, consisting of San Luis Obispo and Santa Barbara counties, encompasses about 3.9 million acres. Service to this area involves construction of Phase II of the Coastal Branch of the California Aqueduct. The Phase II facilities will transport up to 70,486 AF of water to the area. The 70,486 AF per year (AF/YR) represents current entitlements held by San Luis Obispo and Santa Barbara counties; however, Santa Barbara County has the option to buy back an additional 12,214 AF/YR of

SWP water. Alternative route studies for the pipeline are completed. An environmental impact report and an advance planning study are scheduled for completion in September 1990. The two counties will use those reports in deciding whether to construct the facilities.

The Santa Ynez, Santa Maria, and Salinas rivers constitute the major drainages of the Central Coastal service area. Dams and canals have been constructed on those rivers to conserve runoff. No water is imported into the area. Ground water is the main source of water supply. Over-use of the ground water resources has led to overdrafting and water-quality problems in some locations, such as the Santa Maria Valley and southern coastal Santa Barbara County.

Total population in San Luis Obispo and Santa Barbara counties grew from 103,700 in 1940 to 540,000 in 1987. Santa Barbara County is the larger of the two counties. The economy of this area depends on agriculture and related activities. In the coastal lowlands, there is considerable high-value fruit and vegetable farming. In the drier lowlands, inland from the coast, livestock and dry-farmed grains are produced. Manufacturing is limited, but heavy water-using industries—such as petroleum production, food processing, and stone, clay, and glass products—are present. Some mining and military installations also contribute to the region's economy. Recreation and retirement activities are increasing in the coastal communities.

The agricultural preserve program, under the Williamson Act, has helped limit urbanization of agricultural lands in Santa Barbara County. Land committed to public purposes includes Vandenberg Air Force Base, Los Padres National Forest, and other U. S. Forest Service land.

Much of the natural vegetation in the two counties remains relatively undisturbed. Those areas that have been developed have mainly been the valleys, alluvial fans and plains, and terraces.

Due to the wide variety of plant communities in the area, animal populations are extremely diversified. Some of the more common animal species, which occur in most communities throughout the service area, include the mourning dove, the red-tailed hawk, the white-crowned sparrow, the side-blotched lizard, and the western rattlesnake. Because of the overlap between the northern and southern floristic elements, many rare and endangered species inhabit the Central Coastal service area.

San Joaquin Valley Service Area

The San Joaquin Valley service area, which occupies the southern part of the San Joaquin Valley, is situated primarily in Kern and Kings counties and includes a very small area in Stanislaus County.

This service area is in one of the most productive agricultural regions in California. In part of the area on the west side of the valley, the quantity and quality of ground water supplies are poor, and local surface streams are practically nonexistent. With water, however, and the favorable climate, much of the area is conducive to production of a wide variety of orchard, vineyard, and truck and field crops. The two major river drainages in the service area are the Kings and the Kern.

Vast amounts of good quality ground water in the southern end of San Joaquin Valley provide the major water supply for this service area. A large portion of the SWP service area in the San Joaquin Valley overlies the intensively developed San Joaquin Valley ground water basin. The basin extends from the Delta to the Tehachapi Mountains. Parts of the basin have been in overdraft since the 1920s, resulting in land subsidence, increased pumping lifts, and water quality problems.

Water is imported to the southern San Joaquin Valley via the Friant-Kern Canal (CVP) and by the SWP. CVP water is also transported through the California Aqueduct to Kern County under an agreement between Reclamation and the State of California.

The San Joaquin Valley service area is generally arid, sparsely populated, and characterized by large farms. In 1986, the population in the San Joaquin Valley service area was 576,850.

Agriculture and the oil industry are the primary economic activities in this region. Crops raised in the San Joaquin Valley service area include alfalfa, barley, safflower, sugar beets, fruits, vegetables, nuts, cotton, sweet potatoes, cantaloupe, and grapes. Beef cattle, dairy products, and poultry are also significant. Other sources of income include manufacturing, trade, services, and government.

Despite substantial variations in annual SWP deliveries, total irrigated acreage in the service area does not normally fluctuate. Farmers rely heavily on ground water pumping in dry years and local surface water diversions in wet years to maintain the same irrigated acreage.

Details on crop production values, crop labor requirements, and employment and economic trends in this area are available in DWR Bulletin 132-88, Appendix F, *San Joaquin Valley, Post-Project Economic Impact, 1986 and 1987*, December 1988.

Much of the native vegetation in the service area has been replaced by introduced species or disturbed by cultivation or grazing. Major natural vegetation classes found within the valley include grassland, sagebrush shrub, coastal shrub, and hardwood forest-woodland.

Despite the conversion of much of the area to agricultural uses, the wildlife populations of the service area remain extremely diversified. Sizable populations of wildlife can be found in the fringe areas of the service area. Most native fish populations, however, have been eliminated by drainage projects and modifications of natural watercourses. They are now confined to farm ponds, drainage canals, and aqueducts.

Two animals whose native habitats have been reduced considerably by agricultural development are the endangered blunt-nosed leopard lizard and the San Joaquin kit fox. Recovery plans have now been prepared for both species. These are described in *Blunt-Nosed Leopard Lizard Recovery Plan*, Blunt-Nosed Leopard Lizard Recovery Team, January 1980 (draft), and *San Joaquin Kit Fox Recovery Plan*, Thomas P. O'Farrell, U. S. Fish and Wildlife Service, Endangered Species Program, 1983 (draft).

Southern California Service Area

The Southern California service area includes Ventura, Los Angeles, and Orange counties and parts of San Diego, Riverside, Imperial, San Bernardino, and Kern counties.

There are no major rivers in the desert plateau region of this service area. The intermittent streams that flow from the mountains primarily percolate into ground water basins. A limited surface water supply has been developed, and most local water supplies are fully used. In the coastal portion of the basin, most local surface supplies have been developed for flood control, ground water recharge, and water supply.

Ground water supplies a significant portion of the water in this service area. The South Coastal hydrologic basin, which encompasses this service area, has at least 44 major ground water basins. Although further development is possible in a few local areas, some of the basins have been over-used. In 1974, an annual ground water overdraft of 160 TAF led to sea-water intrusion problems in some areas along the coast. Sea-water barrier and artificial recharge programs have been developed to correct these situations.

In Ventura and Los Angeles counties, some SWP supplies are released into natural stream channels. Piru Creek, a tributary to the Santa Clara River, serves as a conveyance to Ventura County users. In Los Angeles County, SWP water is released into Gorman Creek for recreational use as part of the Hungry Valley recreational area. Additional opportunities exist for streamflow augmentation where the East Branch of the California Aqueduct crosses natural streams.

Supplemental water is being imported from three sources:

- Los Angeles Aqueduct from the Owens Valley and Mono Lake Basin, on the east side of the Sierra Nevada, to the city of Los Angeles;
- Colorado River via the Colorado River Aqueduct; and
- SWP.

Many water quality problems exist in this service area. In the coastal area, thermal discharges from electrical generation plants and nutrient overloading of streams cause local problems. In the desert areas, the problems are more general and relate to increasing salinity of both ground water and lakes such as the Salton Sea.

The quality of imported water ranges from less than 220 mg/l total dissolved solids for SWP supplies to 750 mg/l for Colorado River water. In some areas, SWP water is blended with imported Colorado River water to provide a better overall quality.

Land use in the Southern California service area has changed dramatically since the early part of the century, when the citrus industry dominated the economy. Several factors have led to the changes: discovery of oil, construction of the Los Angeles and Colorado aqueducts, increase of port facilities to accommodate shipping and trade brought about by the Panama Canal, location of the 11th Naval District in San Diego, the movie and entertainment industry, and location of heavy industry (especially aircraft and ship building). Together, these factors have caused a shift from agricultural to urban and suburban development.

Since the 1940s, Southern California has changed from a largely rural lifestyle with an agricultural economy to a highly urban-industrial society. The estimated population in 1986 was over 15 million. The rapid economic growth that Southern California experienced during the 1950s and 1960s has slowed, but diversification of the economy continues. This region is the State's leading center of business. Southern California contains the State's largest concentration of manufacturing activity, particularly the aerospace industry. Other major industries include petroleum, fabricated metals, chemical production, food processing, and paper production.

In the coastal areas of Southern California, agriculture remains important economically, despite urbanization. Farms generally produce high value crops on small irrigated parcels. Agriculture is also important in the Colorado Desert, especially in the Coachella and Imperial valleys. Livestock, field crops, truck crops, sugar beets, and cotton are important. Poultry, livestock, and field crops are produced in the Mojave Desert.

While some of the naturally occurring vegetation in the Southern California service area has been altered significantly by urban and agricultural development, a large part of the region (mostly uplands) retains its native cover. The principal vegetation includes chaparral, scrub, grassland, woodland, and forest.

The Southern California service area supports a great diversity of wildlife. The diversity of habitats available in the area, combined with the impacts of a rapidly developing human population, has resulted in a large number of rare and endangered plant and wildlife species. Steps have been taken to preserve habitats that have unique biological significance. One endangered fish, the unarmored *three-spine stickleback, occurs in the service area but is* no longer found in the Los Angeles, San Gabriel, and Santa Ana rivers. The fish population in the Santa Clara River is threatened by increased recreational use and development.

CVP Service Areas

The CVP service areas extend for some 430 miles through much of California's Central Valley, from Clair Engle and Shasta reservoirs in the north to Bakersfield in the south (Figure 4-6). The CVP service areas also include the San Felipe Unit, which is located in the adjacent coastal valley. Much of the environmental setting in the CVP service areas is presented in the previous discussions of the Sacramento and San Joaquin valleys.

At present, Reclamation has contracted to deliver about 8.6 MAF of CVP water, including the sale of interim water. (This includes water for Contra Costa County and from Millerton Reservoir.) CVP water supply contracts have build-up provisions identifying periods during which the contractors may use less than their full entitlement. In 1985, the CVP delivered some 7.4 MAF. Reclamation estimates that, by 2020, nearly all the contracted amount of water will be delivered each year.

The CVP provides water to over 2.8 million acres of agricultural land. Crops grown on California lands irrigated by the CVP had a gross value of about $2.4 billion in 1981.

In addition to irrigation water, the CVP provides water for municipal and industrial use. Nearly 193,000 AF of water was delivered for such uses in 1985. The largest share of this water was delivered through the Contra Costa Canal, as described in the next section. The cities of Redding, Roseville, Placerville, Sacramento, Fresno, and Coalinga also receive all, or a portion of, their water from the CVP.

Contra Costa Water District Service Area

The Contra Costa Water District Service Area, shown on Figure 4-7 is in transition from a rural area to an area dominated by suburban and commercial development. In the 1940s, when the Contra Costa Canal came on line as the first unit of the CVP, 38 percent of the water conveyed went to agriculture and 62 percent to municipal and industrial users. Today, the latter receives 95 percent of the water, with only 5 percent going to agriculture. The county ranks second after Los Angeles among California counties for total fresh water use.

A diversity of industry is located in the county. With its miles of waterfront—linking ocean, river, and overland transportation facilities—the area offers many advantages to heavy industries requiring large supplies of cooling and processing water, large land areas, and access to a deep-water ship channel. Major industry groups in the county requiring the greatest amounts of water are petroleum and coal products, paper and allied products, chemicals and allied products, primary metal industries, and food and related products. Presently, the exceptionally high water needs of the petroleum refineries are largely met with brackish supplies from the south shores of San Pablo and Suisun Bays.

Today, Contra Costa Water District provides for the municipal water needs of about 300,000 county residents. Of the nine Bay area counties, Contra Costa is projected to experience the most rapid future population growth.

The growing trend toward municipal water use increases the need for both improved water quality to meet State and federal standards and improved system reliability to meet peak water demands.

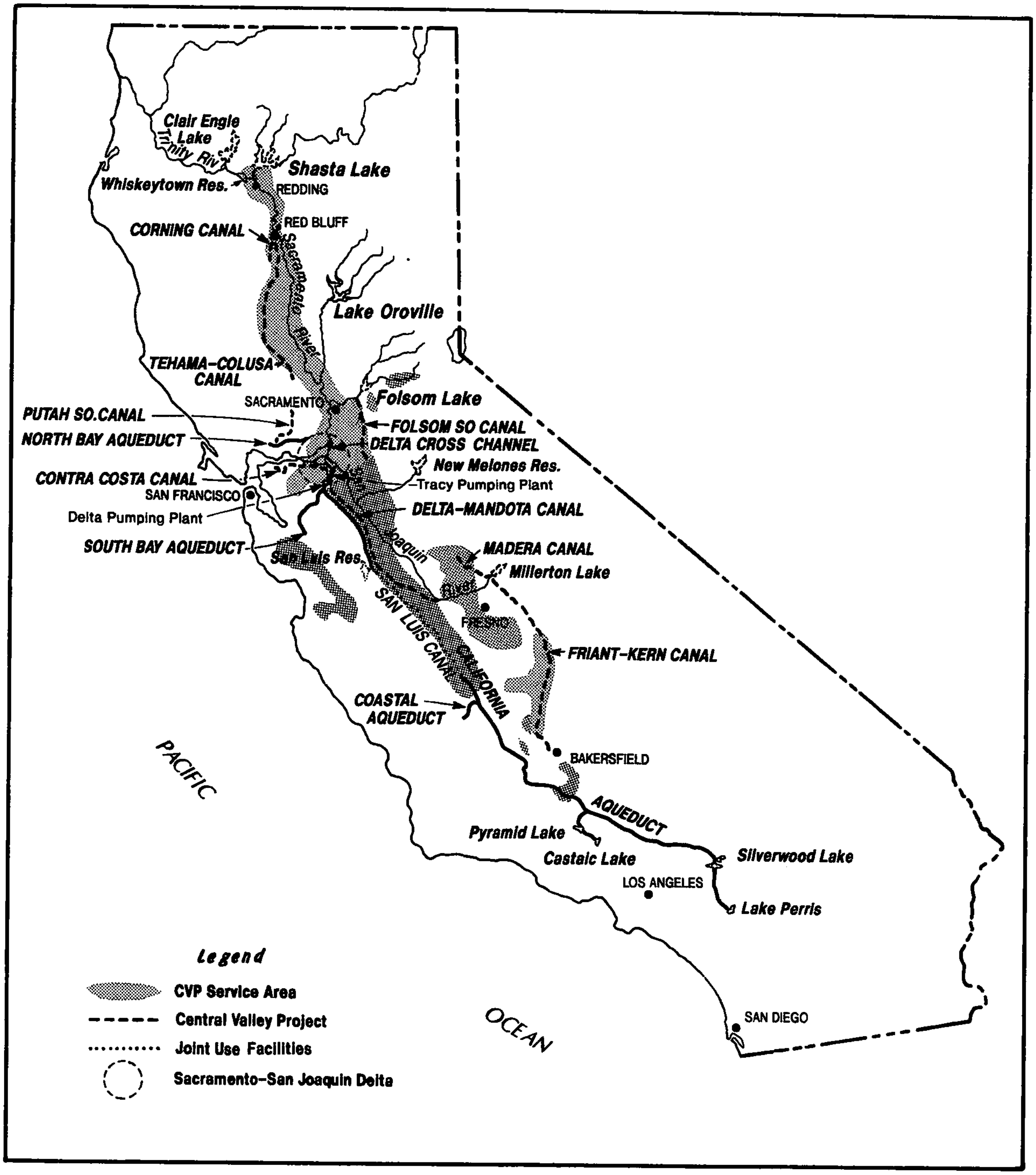


Figure 4-6. The CVP and its Service Areas

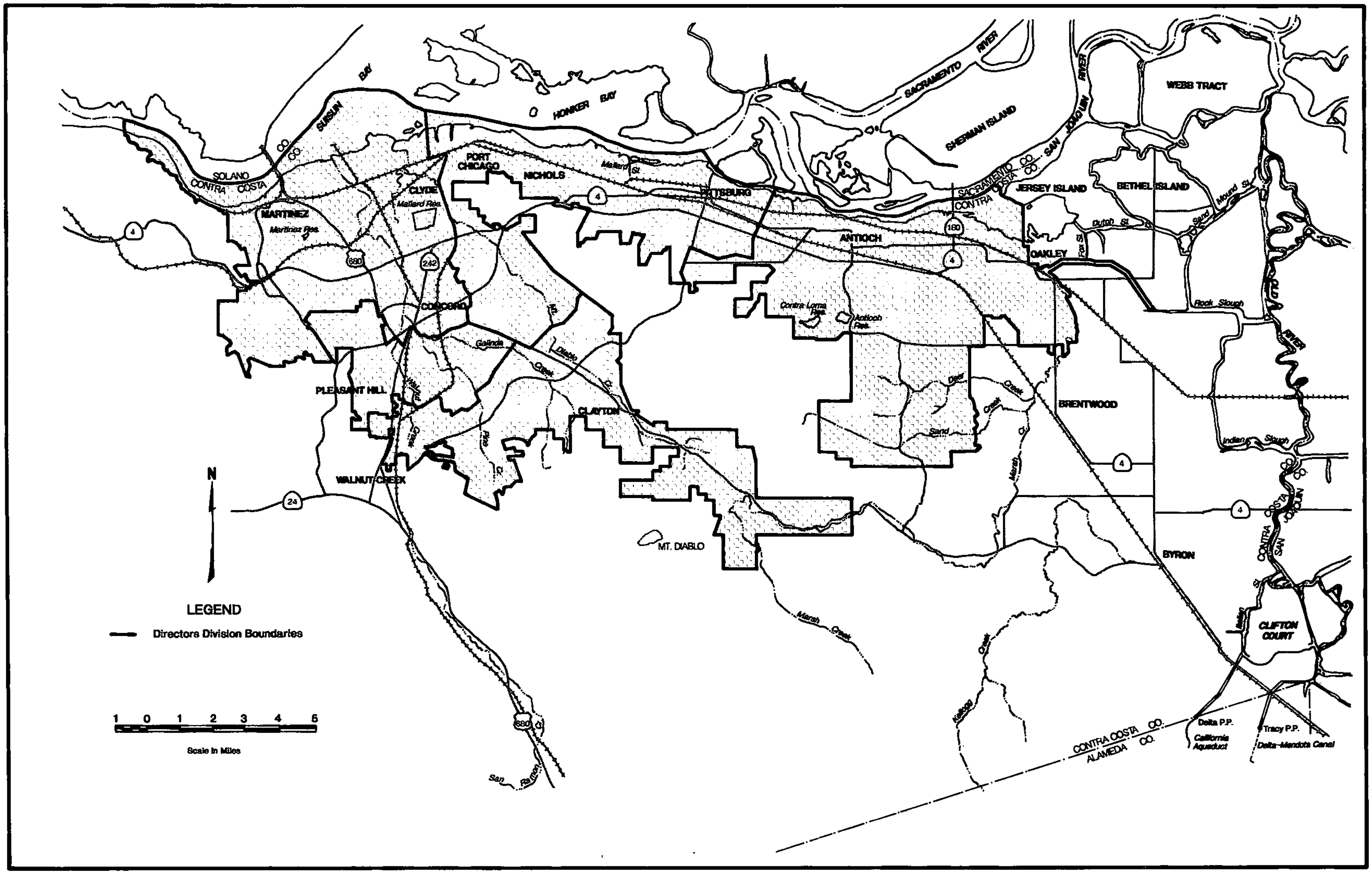


Figure 4-7. Contra Costa Water District Service Area

CHAPTER 5. ENVIRONMENTAL IMPACTS

This chapter analyzes potential environmental impacts from implementation of the North Delta Program (NDP). The analysis includes potential short- and long-term impacts of the NDP on a broad range of physical, chemical, biological, and socioeconomic factors. The analysis includes direct impacts on the Bay-Delta complex, as well as indirect impacts on SWP service areas and other parts of the State affected by SWP operations.

Fishery biologists and environmental specialists of the Department of Water Resources (DWR), the U.S. Bureau of Reclamation (Reclamation), the Department of Fish and Game (DFG), and the U.S. Fish and Wildlife Service (USFWS) assisted in formulating and evaluating incremental impacts of the NDP. Habitat Evaluation Procedures (HEP), which have been standardized, were also used in the evaluation. Where more information was required, additional field studies were also conducted.

During preparation of this EIR/EIS, coordination between local, State, and federal agencies has been extensive. Local land owners have been contacted, and their concerns have been considered.

Four types of engineering studies were used to evaluate impacts: 1) Flood hydrology and hydrodynamic studies using the National Weather Service DWOPER (network option model and the HEC-1 model; 2) water supply studies using the DWRSIM model were conducted, based on 57-year historic hydrology from 1922 to 1978, in which SWP demands were assumed to be 3.8 million acre-feet (MAF); 3) Delta hydrodynamics studies using the DWR/RMA Model and water quality studies using the DWRDSM; and 4) long-range studies used to evaluate project energy and capacity requirements, based on median water supply conditions and gradually increasing project demands.

The water supply studies were used to evaluate potential contributions of the NDP to SWP reliability. Contribution of the project to the dry-period delivery capability was based on the system's performance during the historical critical period 1928 through 1934. Results of this study were used in both the economic analysis of the project and the service area impact analysis. Water supply studies were also used to develop hydrologic conditions for which Delta water quality and hydraulic conditions could be assessed.

Mathematical modeling of Delta hydrodynamic and water quality conditions were used to evaluate potential NDP impact on Delta flows, stages, velocities, and salinities. Hydrodynamic modeling with the DWR/RMA model was used to evaluate the relative effectiveness of a wide range of alternatives in reducing reverse flow. Subsequently, hydrodynamic and water quality modeling with the Fischer Delta model was used to evaluate hydronamic water quality and fishery impacts. Appendix C consists of the important assumptions and results of the mathematical modeling conducted in support of the NDP. Documents describing the mathematical models in more detail, along with their verification, are available for viewing at DWR.

Mathematical modeling of water levels, flows, velocities, and salinity in the Delta channels has greatly aided water resources planning of the Delta. However, some care is required when interpreting the results of such modeling. The mathematical modeling conducted to aid in the evaluation of potential environmental impacts caused by the NDP was generally not intended to provide absolute predictions of future Delta hydrodynamic and salinity conditions. Results of mathematical modeling of Delta conditions under the various alternative actions are often interpreted in terms of the direction and relative magnitude of changes in such variables as water flows and salinity. For this reason, the analysis of how the NDP may affect Delta water levels, flows, velocities, and salinity was based primarily on how the values of these parameters changed under the preferred alternative and other alternatives with respect to the base No-action alternative.

Basic assumptions used for the No-action alternative (base case) and other alternatives, including the preferred alternative, are listed in Appendix C.

Much of the Delta modeling results in Appendix C and in this chapter are therefore provided in terms of changes or improvements in water levels and salinity when compared to the No-action alternative.

The analysis in Chapter 6 assumes SWP demands exceeding 3.8 MAF. The cumulative impact review in Chapter 6is broader in scope, and more general than the impact evaluation in this chapter.

This chapter concludes with a summary of significant operational impacts under the preferred alternative, mitigation options, temporary impacts, and other information

Table 5-1 Summary of Environmental Assessment for the Preferred Alternative		
Subjects	**Environmental Assessment**	**Protection/Mitigation Measures**
Rare, Threatened, & Endangered Species	The project will not be operated or constructed in violation of the Endangered Species Act. Improved flood control can protect Delta lands as foraging habitat for the Aleutian Canada Goose, greater sandhill crane. Swainson's Hawk habitat will be protected.	Participation in the recovery team for winter-run salmon. Study coordination for Delta smelt. Possible development of nesting habitat for Swainson's Hawk.
Resident Fish	Various species of game and non-game resident fish will have increased direct impacts, ranging from 1% to 10%.	Habitat will be improved by creating added shoreline with vegetation.
Fish Food Resources	Reduction in reverse flow will benefit *Neomysis*. More Sacramento River water with low plankton densities will flow into the Delta.	D-1485 and subsequent protection standards. Interagency ecological study program; existing and new fish protection agreements.
Suisun Marsh	Effectiveness of existing physical protective facilities and existing agreement will not be impacted by small outflow changes.	Continued development of planned physical improvements and analysis of operational procedures from ongoing monitoring program.
Construction	Environmental impacts will be short term with no significant long-term impact. Utilization of local construction work forces will preclude other housing and services impacts. There will be some increase in noise, dust, truck traffic, and turbidity; disturbance of vegetation; minor disruption of services (cables, gas lines, etc.) and some minimal recreational inconveniences.	Cal-OSHA regulations; State and federal dredging permits; use of flagmen; dust control; replanting vegetation.
Delta Outflow	Some operational changes will decrease Delta outflow during controlled flow conditions and will have minor impact on the environment. These same changes will reduce reverse flow and provide some environmental benefits. Improved upstream fresh water storage will be available to provide operational flexibility to control salinity and meet water needs.	D-1485 and subsequent protective outflow standards. Existing and new fish protection agreement. Coordinated Operation Agreement.
Delta Outflow Pulses	Minor decrease in number of pulses with unknown impact.	DWR funding contribution to the San Francisco Bay Study.
Cross-Delta Flow	Increase in Cross-Delta flows will have some impact to salmon smolts and striped bass eggs and larvae due to diversion from the Sacramento River.	Planned construction of a large forebay will provide flexibility for gate closures during periods of peak abundance. Also, possible installation of gates on Georgiana Slough will be investigated.

Table 5-1 (Continued) Summary of Environmental Assessment for the Preferred Alternative		
Subjects	**Environmental Assessment**	**Protection/Mitigation Measures**
Local, Municipal and Industrial Use	Possible future water quality improvements to the Contra Costa Cnal with reduced reverse flow. Reduced days of availability of offshore supply.	D-1485 and subsequent protective standards; various industrial water supply contracts; planned provisions to interconnect CCC to Clifton Court Forebay.
Drinking Water Quality	Reduced total dissolved solids, chlorides, bromides, and THM formation potential.	D-1485 and subsequent protective standards; EPA and California Department of Health Services drinking water standards; SWP contract objectives and Delta Health Aspects monitoring.
Agriculture	Use of approximately 1,040 acres of prime agricultural land to construct levees, berms, and channels. Improved flood protection for agricultural lands.	Delta Protection Act, north and south water agency contracts; temporary and drought emergency facilities; flood protection programs.
Water Supply Reliability	Improved reservoir operations can provide more than 200,000—400,000 AF of available storage to allow greater operational flexibility to meet water supply needs and control Delta salinity.	D-1485 and subsequent protective standards; federal regulatory permits; Coordinated Operation Agreement; water supply contracts.
Sedimentation, Scouring, and Seepage	Decreased velocity in the North and South Forks of the Mokelumne River could cause sedimentation; however, no scouring is expected.	Scour and seepage monitoring program will be implemented. Periodic channel dredging will be investigated.
Flooding	Significant flood protection will be provided to north Delta lands and to the towns of Walnut Grove and Thornton.	Improved channels to lower flood stages. Administration of additional coordinated flood control programs will add to protection.
Navigation	Increased channel depths will improve boating access.	Federal regulatory permits.
Recreation	Channel improvement design will incorporate boater destinstioin opportunities.	Davis-Dolwig Act.
Wildlife	Levee setbacks will provide high-quality channel island and water side berm habitat. Loss of 1,040 acres of agricultural land.	Added benefits from participation in the Stone Lakes Wildlife Refuge Program.

Table 5-1(Continued)
Summary of Environmental Assessment for the Preferred Alternative

Subjects	Environmental Assessment	Protection/Mitigation Measures
Salmon and Steelhead	Increased Delta Cross-Channel flows will divert more salmonids into the interior Delta, creating a longer migrating path and higher exposure to predation.	D-1485 and subsequent protection standards provide for flow, salinity, and operational standards for Delta Cross-Channel and SWP and CVP fish protection facilities. Predation program at Clifton Court Forebay. Participation in the recovery team for winter-run salmon. Existing and new fish agreements.
General impact on Striped Bass	Beneficial changes will occur from reduced salinity and reverse flows. Some of these benefits will be reduced by increased Delta Cross-Channel flows and increased annual exports. Outflow changes will have minimal effects.	D-1485 and subsequent protection standards provide for flow, salinity, and operational standards for the Delta Cross-Channel and SWP and CVP fish protection facilities. Existing and new fish agreements.
Direct impact on Striped Bass	Annual reduction in striped bass yearly equivalent losses.	D-1485 and subsequent protection standards; predation control programs.
Wetlands	Increase in riparian/wetland area associated with channel enlargement. Implementation of NDP may reduce the severity of flooding in the Cosumnes River Preserve and Stone Lakes area.	DWR participation in wildlife habitat acquisition for Stone Lakes Refuge. DWR participation to mitigate changes in flooding regime to Cosumnes River Preserve and Stone Lakes Refuge.

required by the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA).

Flood Control

The most pressing problem in the north Delta study area is repeated and extensive flooding of the leveed tracts and islands. Levee failures have become common. Since 1980, there have been 14 such occurrences in the north Delta. required by the California Environmental Quality Act (CEQA) and NAtion Environmental Policy Act (NEPA). Both limited channel capacities and inadequate levees contribute to this critical problem.

Delta levees fall into two main categories: project levees and nonproject levees (see Figure 1-2). Project levees are part of the Federal Flood Control Project, and primarily line the Sacramento River, adjacent sloughs, and the San Joaquin River in the southeast portion of the Delta. These levees, which constitute about 35 percent of the total, provide higher levels of flood protection. Nonproject levees constitute the remaining 65 percent and are maintained by island landowners or local levee and reclamation districts to varying and generally less stringent standards than project levees. Nonproject levees generally have less freeboard, and therefore less protection, against overtopping and are generally less stable. Levees along the Mokelumne River system and tributary sloughs are nonproject levees.

The February 1986 flood demonstrated the urgent need for new flood control work. During the flood, massive flows from the Cosumnes River, Mokelumne River, and local creeks poured into the northeast Delta. The peak flows far exceeded channel capacities, and spread out over low-lying areas between Freeport and Thornton, particularly in the Beach-Stone lakes area and at the confluence of the Cosumnes and Mokelumne rivers. While this spreading greatly attenuated the peak flows into the northeast Delta, there was still inadequate capacity in the north and south forks of the Mokelumne River to carry the remaining flows. McCormack-Williamson Tract and Glanville Tract were inundated. Levees on Deadhorse Island and Tyler Island failed after they were overtopped. The levee protecting New Hope Tract near Thornton failed due to structural weakness. Inundation of these larger islands and tracts lowered the floodwaters and probably saved other islands from flooding. For a short time, water flowed over the Delta Cross Channel gates from the Sacramento River into the Mokelumne River system.

The 1986 flooding forced evacuation of 1,600 people from small towns and various homes and businesses in the area, caused $20 million worth of direct damage, and flooded Interstate 5 and numerous local roads. Had the U.S. Army Corps of Engineers (with State and local assistance) not raised a temporary levee south of Walnut Grove, the town would have flooded, and residents would have been driven from their homes. This near disaster demonstrated the urgent need for a flood control project.

The north Delta study area receives drainage from about 2,000 square miles of watershed, including the Morrison Stream Group (180 sq. mi.), the Cosumnes River (870 sq. mi.), Dry Creek (330 sq.mi.), and the Mokelumne River (670 sq. mi.).

The Morrison Creek Stream Group is composed of Morrison, Elder, Unionhouse, and Laguna Creek. These streams, located in Sacramento County southeast of the city of Sacramento, flow generally westward, joining in the vicinity of the Beach-Stone Lakes area. Drainage continues south through the Beach-Stone Lakes area. Flows are then discharged into Snodgrass Slough at Lambert Road and through Snodgrass Slough around Dead Horse Island and into the Mokelumne River system (see Figure 2-2).

The Cosumnes River, Dry Creek, and the Mokelumne River originate in the central Sierra Nevada and foothills. Flows from these streams converge just upstream from MacCormack-Williamson Tract and flow around it via Lost Slough and the main stem Mokelumne River. Flows from Lost Slough, the Mokelumne River, and Snodgrass Slough converge near New Hope Landing, and enter the severely restricted North and South Forks Mokelumne River channels. The North and South Forks of the Mokelumne River must carry all the flood flows through the north Delta.

There are no significant flood control reservoirs on the Morrison Creek, Cosumnes River, or Dry Creek watersheds. The Mokelumne River has 11 reservoirs with capacities exceeding 1,000 AF. Camanche Reservoir is the most important, with a total storage capacity of 431,000 AF and a maximum flood control reservation of 200,000 AF. During the 1986 flood, releases from Camanche were limited to about 5,000 cfs, attributable to Camanche and upstream reservoirs. It is estimated that without these reservoirs, peak flow at the current location of Camanche Reservoir would have been about 44,000 cfs.

The Corps is currently conducting a reconnaissance-level study of potential flood control reservoir sites on the Cosumnes and Mokleumne rivers. The study is scheduled to be completed in December 1990.

Significant flood storage is also provided in the north Delta Study Area. The area east of Franklin Road, where the Cosumnes River, Dry Creek, and Mokelumne River channels converge, has historically served as a flood detention area. The North and South Stone Lakes area north of Lambert Road provides about 74,000AF of storage when the elevation at Lambert Road reaches 14 feet. Historically, water has spread out over these areas due to the very limited channel capacity in the North and South Forks of the Mokelumne River downstream.

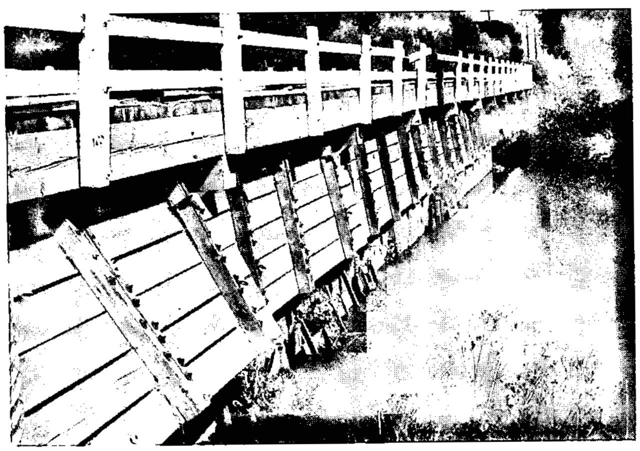
The Beach-Stone Lakes area was originally an overflow area of the Sacramento River. The flood plain in this area consists of valley lands ranging in elevation from a few feet below sea level to 20 feet above mean sea level. Currently, this area is primarily used for agriculture. It is projected that future land use in the Beach-Stone Lakes area will include gradual development of the area east of I-5 and essentially little or no change in land use west of I-5. Beach Lake, North Stone Lake, and South Stone Lake receive inflow from return irrigation and municipal drainage water as well as backwater from the Sacramento-San Joaquin Delta. Some flooding occurs almost every year, and damaging floods occur once every 3 years on the average.

The FWS has proposed the creation of a national wildlife refuge in the portion of this area west of I-5. This proposal is compatible with DWR's planning program and may provide opportunities for interagency cooperation in mitigation planning and habitat improvement.

Upstream development in the Morrison Creek watershed could increase peak inflows and lead to further threat of flooding in the north Delta. The Corps of Engineers has conducted engineering and design studies for the Morrison Creek stream group. According to the Corps' March 1987 report on the studies, reservoir storage to regulate Morrison Creek floodflows is not economically feasible. An alternative suggested by the Corps was to improve about 25 miles of channel and modify the outlet structure and embankment on Lambert Road.

Sacramento city and county have undertaken some channel and levee work in the Morrison Creek drainage basin and will probably complete most channel improvements within the next 2 or 3 years.

Lambert Road, which runs east–west about 9 miles south of Freeport, caps a levee which generally prevents floodwaters from the Cosumnes River, Dry Creek, and the Mokelumne River from flowing north into the Stone Lakes basin. The road generally lies about 18 feet above mean sea level, above the currently established National Flood Insurance Program 100–year–flood elevation of 15 feet. Lambert Road crosses Snodgrass Slough about 1.7 miles west of I–5, on an old, structurally deficient bridge (now closed, due to safety concerns). Seven culverts, four feet in diameter and fitted with flap gates, and ten four foot by ten foot wooden flapgates allow the Stone Lakes Basin to drain into Snodgrass Slough, while preventing backflow from the south. The bridge deck, and the approach road on either end of the bridge, are about 11 feet above mean sea level. Leakage through the deteriorating flap gates and overflow over this low–lying portion of Lambert Road allow flow from the south during major flood events.



Lambert Road Bridge

During the February 1986 flood about 13,000 AF of water flowed north over Lambert Road. In addition, some water from the Cosumnes and Mokelumne rivers spilled over Lambert Road just east of the Western Pacific Railroad embankment, and flowed westward into the south Stone Lakes area. The combined effect of local inflow from the Morrison Creek Stream Group, spill over Lambert Road at Snodgrass Slough, and spill over Lambert Road east of the Western Pacific Railroad embankment resulted in a peak flood elevation of about 14.1 feet at the Lambert Road bridge.

Sacramento County is currently conducting an environmental impact study and has initiated design work for construction of a Lambert Road bridge and flood control structure. Most of the cost of the new structure will be borne by residential development in the Laguna area east of I–5.

Several federal, State, and local agencies are working to alleviate flood problems in the north Delta area. Current programs, with a variety of authorizations, implementation schedules, and budgets, overlap and conflict at times. There is a continuing need for coordination between these programs.

Reclamation Districts in the north Delta study area, as well as the rest of the Delta, are working to meet FEMA Hazard Mitigation Plan levee standards (Figure 3–3). The deadline for compliance with FEMA HMP standards is September, 1991. Reclamation districts not in compliance with these standards will no longer be eligible for federal disaster assistance during future floods.

Levee improvements in the Delta, which reduce the probability of levee failures and flooding of the leveed islands and tracts, may result in higher stages in the channels, creating a back–water effect upstream.

Recent Delta levee legislation, Senate Bill 34, was passed by the California Legislature and signed by the Governor on March 12, 1988. This bill increases the financial assistance to Delta reclamation and levee districts maintaining nonproject levees. The legislation contains a provision for the local districts to pay the first $1,000 for each mile of levee maintenance and rehabilitation; the State will then pay up to 75 percent of the cost exceeding $1,000 per mile. This legislation will provide $6 million annually for 10 years.

Senate Bill 34 also contains a new Delta Flood Protection Fund of $6 million annually for 10 years for special flood control projects in the Thornton–Walnut Grove area and for the eight western Delta islands that are vital to Delta water quality. In addition, the legislation calls for $5 million annually for 10 years for environmental mitigation projects.

Planning for the improvement of 5.4 miles of levees protecting Thornton is now under way. Construction is expected to begin in 1991.

The Corps continues to study the possibility of a federally authorized flood control project in the Delta, which would provide federal assistance for improving the levees. A reconnaissance level investigation is now under way and is scheduled for completion in September 1991.

The NDP has focused on channel enlargement as a key objective because this would reduce flood stages throughout the study area. Levee improvements will further improve flood protection; however, levee improvements alone will tend to shift the risk of inundation from one area to another, without reducing the overall flood danger.

To evaluate the impacts of potential channel enlargement alternatives, DWR and the Corps conducted several interrelated studies, which included the following elements:

- reconstruction of the February, 1986 flood hydrology for the north Delta study area, including estimated inflows from the Morrison Creek Stream Group, the Cosumnes River, Dry Creek, and the Mokelumne River at the boundaries of the study area;
- evaluation of the impact of reservoir storage on runoff from the Mokelumne River watershed during the February 1986 flood;
- development of a hypothetical 100-year-flood hydrology for the north Delta study area, including estimated inflows from the Morrison Creek Stream Group, the Cosumnes River, Dry Creek, and the Mokelumne River at the boundaries of the study area; and
- development of a computer model to simulate flooding in the network of channels and overflow areas in the north Delta study area.

The inflows to the north Delta cannot be measured directly because as they approach the area, they spread out, moving overland and in a complex network of poorly defined channels and overflow areas. To estimate the timing and magnitude of flows at the study area boundary, a combination of flow measurement, flood routing, and local rainfall runoff analysis is required. Flood routing and local rainfall–runoff analysis were conducted, using HEC–1 (Appendix C).

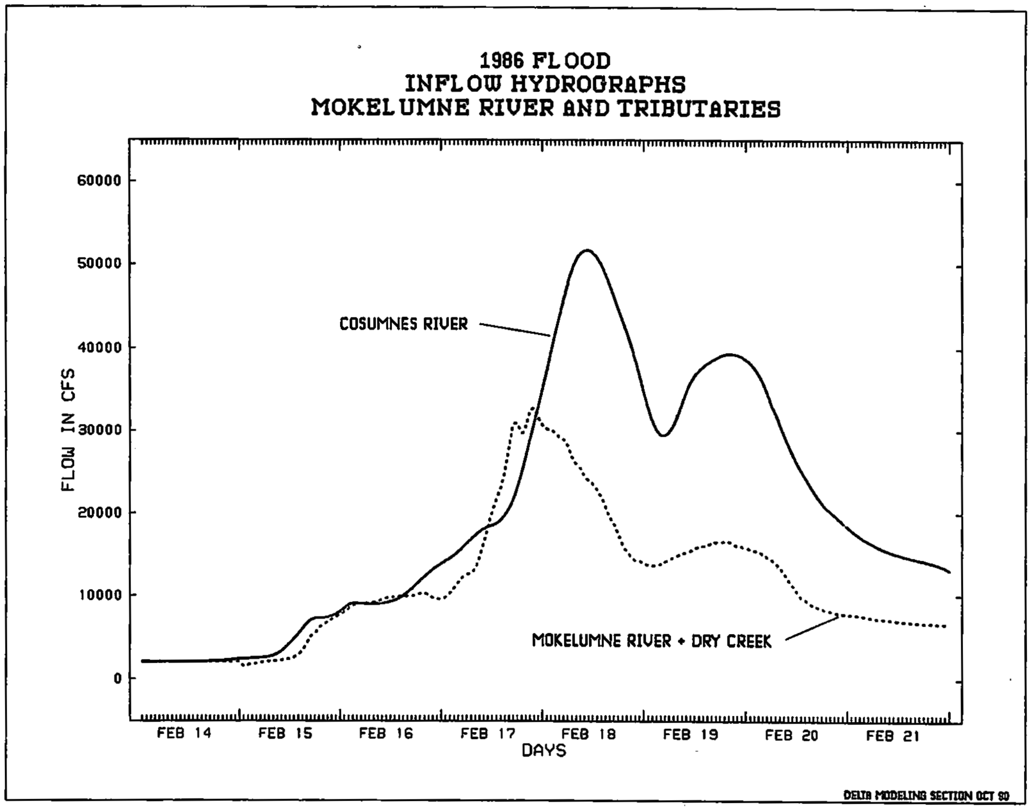
Impacts on flood flows, stages, and velocities were analyzed, using a Dynamic Wave Operational Model (DWOPER) with a network option. The model, developed by Dr. D. Fread of the National Weather Service Office of Hydrology, was selected because it can simulate the extremely complex flood hydrology of the north Delta study area. It effectively models flood wave transients, channel flows, water storage in overflow areas, levee failures and island flooding, tidal effects, impacts of hydraulic structures—such as the existing and proposed Lambert Road structure—and the distribution of flood flows through a complex network of channels. About 118 cross sections were compiled from a number of sources to describe the channel geometry of the study area.

In a typical flood modeling effort the model is calibrated by adjusting model parameters to achieve the best fit to one or more storms for which data is available. Because model parameters have been "tuned" to fit specific storms, it is necessary to verify that the model realistically simulates the prototype flood hydrology by simulating one or more floods to which the model has not been calibrated. Once verified, the model can be used, with the appropriate level of caution, for alternative analyses or other studies.

The calibration step is optional, because model parameters can be estimated directly from field investigations without regard for model performance. The verification step is essential, however, because it provides the only way to evaluate the accuracy and reliability of the model.

In the north Delta flood analysis the DWOPER network model was not calibrated. Instead, model parameters and inputs were measured or estimated directly from field investigations, recorded precipitation, flow, and stage data, and other observations, after which model performance was verified to the extent possible by simulating the February 1986 flood (Figure 5–1).

The results of the February 1986 flood verification run are shown in Appendix C and summarized in Table 5–2a. The



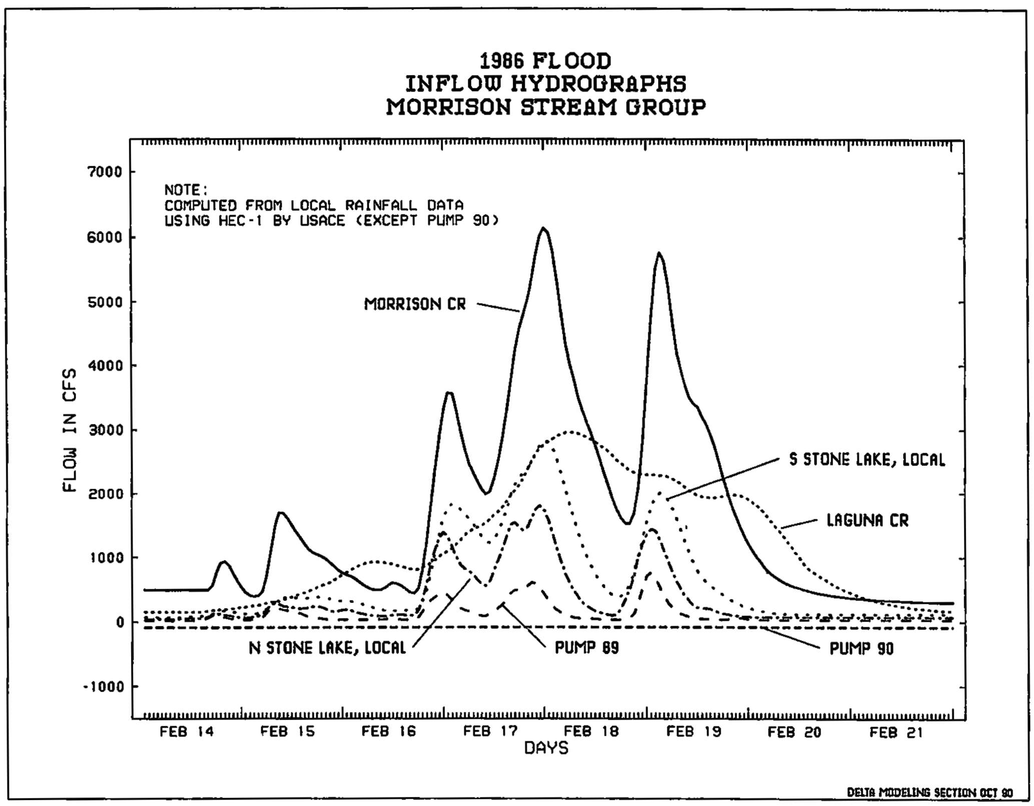


Figure 5–1. 1986 Flood Hydrographs for the Mokelumne River and Morrison Creek

first column lists the recorded February 1986 stages, and the second column shows the DWOPER network model simulation results, based on simulation of the actual levee breaks, with current channel geometry ("no action alternative") and the current Lambert Road structure. The results suggest that the model reproduces all the major features of the February 1986 flood, but is unable to replicate the flood exactly.

The discrepancy between the actual and simulated flood occurs in part because the verification data is incomplete and because some simplifying assumptions were required to facilitate the modeling. Among the significant potential sources of discrepancy in modeling the 1986 flood are the following:

- Although the times of levee failures during the flood are fairly well established, the resultant levee breach hydrographs cannot be reconstructed with a high degree of confidence. The island flooding volumes were estimated from topographic maps and flood elevation estimates, while peak flows and hydrograph durations were based on field observations, breach size, and other factors.

- As described earlier, the inflows to the north Delta area are estimated rather than measured directly, using rainfall–runoff simulation, flood routing, upstream flow data and precipitation data. Thus, considerable uncertainty remains about what the true inflows were at the model boundaries.

- During the flood a number of houseboats and other craft broke free of their moorings and were carried downstream to pile up at the Walnut Grove–Thornton Road Bridge at New Hope Landing. This obstructed the flow and, according to eyewitness accounts, caused a considerable back water effect which was not simulated in the model.

- During the flood some overflow from the south entered the Stone Lakes area by spilling over Lambert Road on the east side of the Western Pacific Railroad tracks, then flowing westward on the north side of Lambert Road. The Corps estimated that about 1500 acre–feet entered the Stone Lakes Basin by this path. This overflow was not taken into account in the model because it represents a small fraction of the total overflow across Lambert Road and including it would make the modeling problem considerably more complex.

- The DWOPER network model requires that there be a single downstream boundary where flows exit, whereas in fact, flow drains into the San Joaquin River via Little Potato Slough on the east and the South Fork Mokelumne River on the west. To deal with this difficulty, the downstream model boundary was fixed just upstream of Georgiana Slough on the South Fork Mokelumne River, and the Little Potato Slough channel capacity was added to the South Fork Mokelumne channel capacity in the reach west of Terminous. As a result, the model tends to slightly over–estimate stages along the South Fork Mokelumne River between Hog Slough and Georgiana Slough, because the simulated flow path is longer than in the actual channels.

- The model simulated island flooding by creating outflows from the designated channels which approximate the timing, peak flow, duration, and volume of the actual levee breaks. The model did not simulate the return flow into the river channels which occurred when levees at the lower ends of the islands were overtopped and breached. Thus, the model underestimates effective channel capacity and storm volume on the recession of the flood.

Despite these data and modeling errors and simplifications, the model performed reasonably well and was judged acceptable for conducting the comparative analyses required in this EIR/EIS. However, the model should not be used to determine absolute stages such as required under the National Flood Insurance Program.

A synthetic 100–year flood was developed to facilitate the analysis of NDP alternatives as well as other potential changes in the study area. The 100–year flood volumes were determined from a regional flow–duration–frequency analysis. The December 1955 flood was used as a prototype for creating the 100–year storm hydrographs with the appropriate 3–day, 7–day, and 15–day volumes. A 100–year storm centered over the Cosumnes River basin would have the greatest impact on the north Delta study area and was selected for use in the alternative analysis. The Morrison Creek Stream group, Dry Creek, and the Mokelumne River would have concurrent floods of less than 100–year intensity. The development of the 100–year flood hydrology is described in detail in the Corps Office Report, *Mokelumne River, California, One Percent Flood at Franklin Road, Hydrology,* May 1990.

In the course of this analysis it was found that the synthetic 100–year event and the February 1986 events were roughly comparable in magnitude and could be used as alternative 100-year flood scenarios (Figures 5-1 and 5-2). Also, the impact of the Lambert Road structure on flood stages (both existing and proposed) depends a great deal on the relative timing and magnitude of north Delta inflows. A simulated storm centered over the Morrison Creek Basin would tend to show relatively less impact attributable to the structure because the Stone Lakes basin would be filled from Morrison Creek inflow, leaving less room for overflow from the south. Conversely, a storm centered over the Cosumnes River watershed would tend to show a greater impact attributable to the structure because more storage space north of Lambert Road would be available to receive peak inflow from these larger watersheds.

The February 1986 flood had comparatively greater flows in the Morrison Creek Basin than the hypothetical 100-year flood, as shown in Table 3-1.

Accordingly, for the preferred alternative (5B), impacts were analyzed for both the 100-year and February 1986 flood (Tables 5-2a and 5-2b; and Figures 5-1 and 5-2).

While levee breaks during the February 1986 flood are a matter of record, the timing and location of levee breaks in future floods are unknown. On the other hand, levee breaks can profoundly affect peak flood stages and cannot be ignored in simulating major flood events. If a levee fails just prior to the time of peak flooding, water rushing through the breach can attenuate the peak. A levee failure which allows an island to flood completely before the time of peak flooding will have no impact on the peak stage: It simply results in storage of water which would otherwise have flowed out of the area. A levee failure occurring after the peak flooding, such as occurred on New Hope Tract, will obviously have no impact on peak stages.

In response to both the uncertainty and the importance of levee failures in modeling the 100-year flood, two different levee break scenarios were simulated in evaluating the impact of the preferred alternative.

In Levee Break Scenario 1, it was assumed that McCormack-Williamson Tract levees fail when the Mokelumne River stage between I-5 and New Hope Landing reaches 13 feet. In Levee Break Scenario 2, it was assumed that both McCormack-Williamson Tract and Glanville Tract fail at this water level. Levees protecting other north Delta tracts and islands have been or are being raised and improved to comply with FEMA Hazard Mitigation Plan Standards, so it is assumed that they will not fail in the 100-year flood. Levee Break Scenario 2 was judged to be most likely in an extreme flood, because McCormack-Williamson Levees cannot be raised and the east levee protecting Glanville Tract remains vulnerable to failure.

Table 5-2b shows the 100-year flood analysis, conducted for both levee break scenarios, with and without the proposed Lambert Road structure. The last 4 columns of Table 5-2a shows the simulations using Levee Break Scenario 2 and February 1986 hydrologic inputs. In these simulations the February 1986 flood is used as an alternative 100-year flood, and can be compared to the last 4 columns of Table 5-2b.

The 100-year flood was used with levee break Scenario 2, assuming the current Lambert Road structure remains, to compare the impacts of north Delta channel enlargement alternatives on stages at key locations (Table 5-3).

No-Action Alternative

Under the No-action alternative, it is expected that current trends and activities impacting flood stages will continue. Reclamation Districts in the north Delta will continue to upgrade levees to meet the FEMA deadline for compliance with Hazard Mitigation Plan levee standards.

Development in the Morrison Creek Stream Group basin will continue at the current rapid rate, which will result in greater runoff and a more rapid concentration of runoff. Figure 5-2 shows the estimated 100-year-flood flow for the basin, using the December 1955 flood as a temporal pattern, for current conditions and assuming current development of the watershed. Development is expected to increase peak flow by about 37 percent, from 9,700 cfs to 13,300 cfs.

This development, under the No-action alternative, would increase the 100-year-flood stages in the South Stone Lake area by about 0.3 foot. The impact downstream from Lambert Road would be less—about 0.2 foot at New Hope Landing and 0.1 foot at Benson's Ferry.

Sacramento County may proceed with construction of a new Lambert Road bridge and flood control structure. This new structure would effectively prevent floodwaters from the Mokelumne and Cosumnes Rivers from flowing north into the Beach-Stone Lakes Basin. It would also allow the Beach-Stone Lakes Basin to drain more freely when stages downstream from Lambert Road permit. The effect of the new Lambert Road structure, under the 100-year-flood scenario, would be a reduction in peak stage north of Lambert Road of about 2.4 feet, and a corresponding increase in stage downstream of about 1.6 feet. (Table 5-2b, Levee Break Scenario 2, No-action Alternative, Current Lambert vs. Proposed Lambert columns). The stage increase at New Hope Landing would be about 1.4 feet, and at Benson's Ferry, it would be about 0.6 foot.

The estimated impacts on 100-year-flood stages under the No-action alternative, with the current level of development in the Morrison Creek Stream Group basin, are summarized in Table 5-2b. If the 1986 flood flows were used as a basis for comparison, rather than the hypothetical 100 year flood, the impact of the Lambert Road structure on flood stages would be somewhat less. The reason is that the 100-year event that results in the greatest overall flooding in the north Delta study area would be centered over the Cosumnes River basin, a mountain watershed with no flood storage reservoirs. The Morrison Stream Group, Dry Creek, and the Mokelumne River basins would receive proportionately less precipitation, being further from the storm center. During the 1986 flood, however, intense thunderstorms over the Sacramento area resulted in proportionately greater runoff from the Morrison Stream Group, resulting in a larger volume of water flowing into the Beach-Stone Lakes basin, and thus, higher stages upstream from the Lambert Road structure.

The effect of the new Lambert Road structure, under this flood scenario, would be a reduction in peak stage north of Lambert Road of about 0.9 feet, and an increase in stage downstream of about 1.3 feet (Table 5-2a, Levee Break Scenario 2, No Action Alternative, Current Lambert vs. Proposed Lambert columns). The stage increase at New Hope Landing would be about 1.1 feet, and at Benson's Ferry, it would be about 0.3 feet.

Whereas this analysis has focused on the 100-year-flood scenario, flood stages from lesser storms would also be affected. The new Lambert Road bridge can be expected to allow Morrison Creek drainage to exit more quickly and eliminate all backflow through the existing flap gates, thus reducing flood stages in the Beach Stone Lakes basin even when flood stages downstream do not exceed 11 feet (the

Table 5-2A
Impacts on February 1986 Flood Stages[1]

	Recorded	DWOPER/NETWORK Model Simulation Results					
		Actual Levee Breaks[2]		Levee Break Scenario 2: McCormack Williamson Tract & Glanville Tract Flood			
		No-Action Alternative		No-Action Alternative		Preferred Alternative	
Location	Feb. 1986 Stages	Current Lambert	Proposed Lambert	Current Lambert	Proposed Lambert	Current Lambert	Proposed Lambert
Column	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Mokelumne-South Fork							
Benson's Ferry	18.3	17.7	18.1	17.8	18.1	13.5	13.5
New Hope Landing	13..1[3]	12.1	13.3	12.2	13.3	8.9	8.9
Hog Slough	-	7.2	7.2	7.2	7.2	7.1	7.1
Terminous	-	7.0	7.1	7.1	7.1	7.1	7.1
Junction North Fork	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Snodgrass—North Fork							
Lambert Road, north	14.1	13.5	12.8	13.7	12.8	10.2	10.2
Lambert Road, south	14.1	13.7	15.1	13.8	15.1	10.5	10.5
Twin Cities Road	14.2	13.7	15.1	13.8	15.1	10.5	10.5
Delta Cross Channel	13.9	12.6	13.8	12.6	13.8	9.3	9.3
Junction North Fork	12.0[4]	12.0	13.1	12.0	13.1	8.7	8.7
Mid-Staten Island	-	7.6	7.8	8.0	8.1	7.2	7.2
Junction South Fork	7.0	7.0	7.0	7.0	7.0	7.0	7.0

[1]Note: Stages are referenced to 0.0'. Stages are approximate and presented for comparison only.
[2]Levee breaks on McCormack-Williamson Tract, Glanville Tract, Dead Horse Island, Tyler Island, and New Hope Tract.
[3]High water mark upstream from Walnut Grove-Thornton Road Bridge.
[4]High water mark 100 feet upstream from Giusti's Restaurant.

Table 5-2B
Preferred Alternative (5B) Impacts on 100-Year Flood Stages[1]

Location	Levee Break Scenario 1				Levee Break Scenario 2			
	No-Action Alternative[2]		Preferred Alternative[3]		No-Action Alternative[2]		Preferred Alternative[3]	
	Current Lambert	Proposed Lambert	Current Lambert	Proposed Lambert	Current Lambert	Proposed Lambert	Current Lambert	Proposed Lambert
Column	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Mokelumne-South Fork								
Benson's Ferry	18.9	19.8	14.8	14.8	18.5	19.1	14.6	14.6
New Hope Landing	14.0	15.5	10.8	11.0	13.4	14.8	10.5	10.6
Hog Slough	8.3	8.6	8.6	8.6	8.2	8.4	8.5	8.5
Terminous	8.0	8.0	8.0	8.0	7.9	8.0	8.0	8.0
Junction North Fork	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
Snodgrass—North Fork								
Lambert Road, north	13.9	11.5	11.0	10.7	13.4	11.4	10.8	10.6
Lambert Road, south	15.4	17.2	12.0	12.3	14.8	16.4	11.7	11.9
Twin Cities Road	15.4	17.2	12.0	12.3	14.8	16.4	11.7	11.9
Delta Cross Channel	14.4	16.0	11.2	11.4	13.9	15.2	10.9	11.0
Junction North Fork	13.9	15.3	10.5	10.7	13.3	14.6	10.3	10.4
Mid-Staten Island	9.3	9.9	8.7	8.8	9.2	9.6	8.6	8.6
Junction South Fork	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7

Levee Break Scenario 1: McCormack Williamson Tract floods.
Levee Break Scenario 2: McCormack Williamson Tract and Glanville flood.

[1]Note: Stages are referenced to 0.0'. Stages are approximate and presented for comparison only.
[2]The current level of development in the Morrison Creek Stream Group basin is assumed. With ultimate development in the basin, add about 0.3 feet to stages upstream of Lambert Road, 0.2 feet to stages between Lambert Road and New Hope Landing, and 0.1 feet to the stage of Benson's Ferry.
[3]Impacts of development in the Morrison Creek Stream Group basin would be less than noted in Footnote 2 (above).

elevation at which the current structure is overtopped). There would be corresponding increases in flood stages downstream.

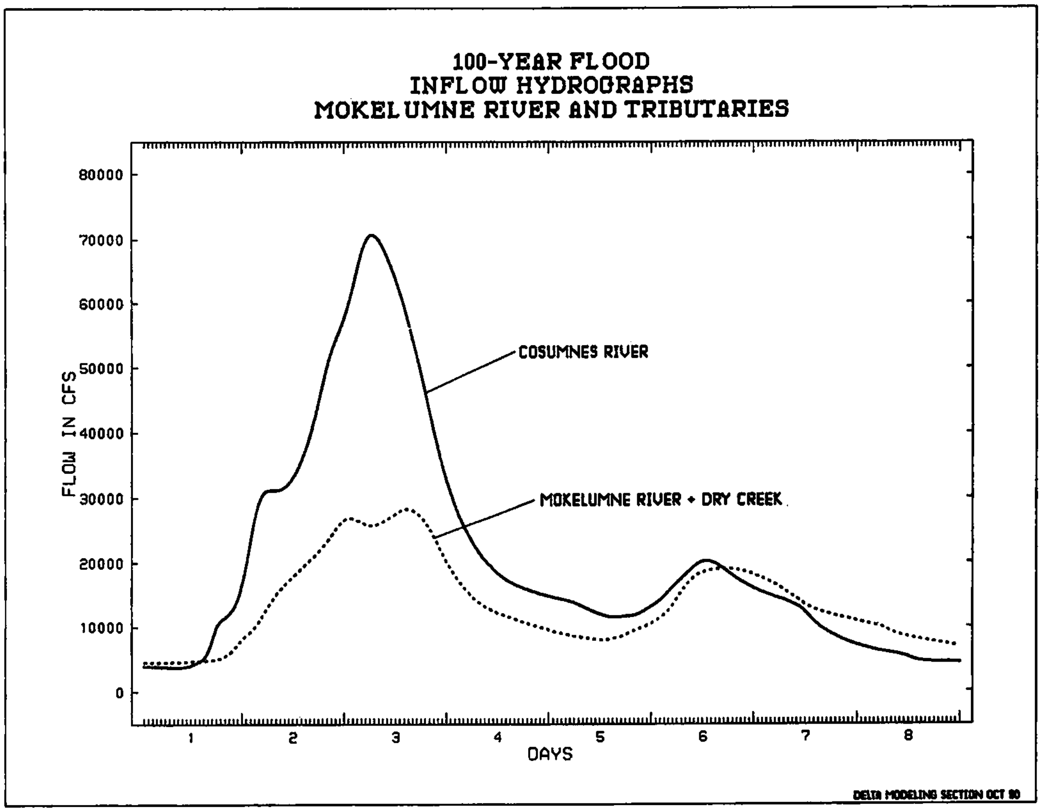
Preferred Alternative

The preferred alternative, 5B, as well as alternative 5A, include channel enlargement along the Mokelumne River from I-5 to New Hope Landing, then along the North Fork Mokelumne River to the San Joaquin River. The South Fork Mokelumne River and portions of Snodgrass Slough would be dredged. These actions will result in significant reductions in peak 100-year-flood stages throughout the north Delta study area under all scenarios considered.

The impact on flood stages was evaluated for the February 1986 flood hydrology, for the synthetic 100-year flood hydrology with levee break scenarios 1 and 2, with and without reconstruction of the Lambert Road Structure, and with and without ultimate development in the Morrison Creek Stream Group basin. The results are summarized in Tables 5-2a and 5-2b.

As the tables show, the simulated reduction in flood stages with implementation of the preferred alternative varies with the location in the study area and the planning assumptions employed. At New Hope Landing the stage reduction varies from 2.9 feet to 4.5 feet. The lowest impact, a 2.9 feet reduction in stage, is computed using the 100-year flood with Levee Break Scenario 2 and the current Lambert Road Structure (Table 5-2b, column 5 vs. column 7). The greatest impact, a 4.5 feet reduction in stage, is computed using the 100-year flood with Levee Break Scenario 1 and the proposed Lambert Road Structure (Table 5-2b, column 2 vs. column 4).

Upstream of New Hope Landing the stage reductions would be somewhat greater; downstream of New Hope Landing the stage reductions diminish. The model indicates that stages could increase in the vicinity of Hog



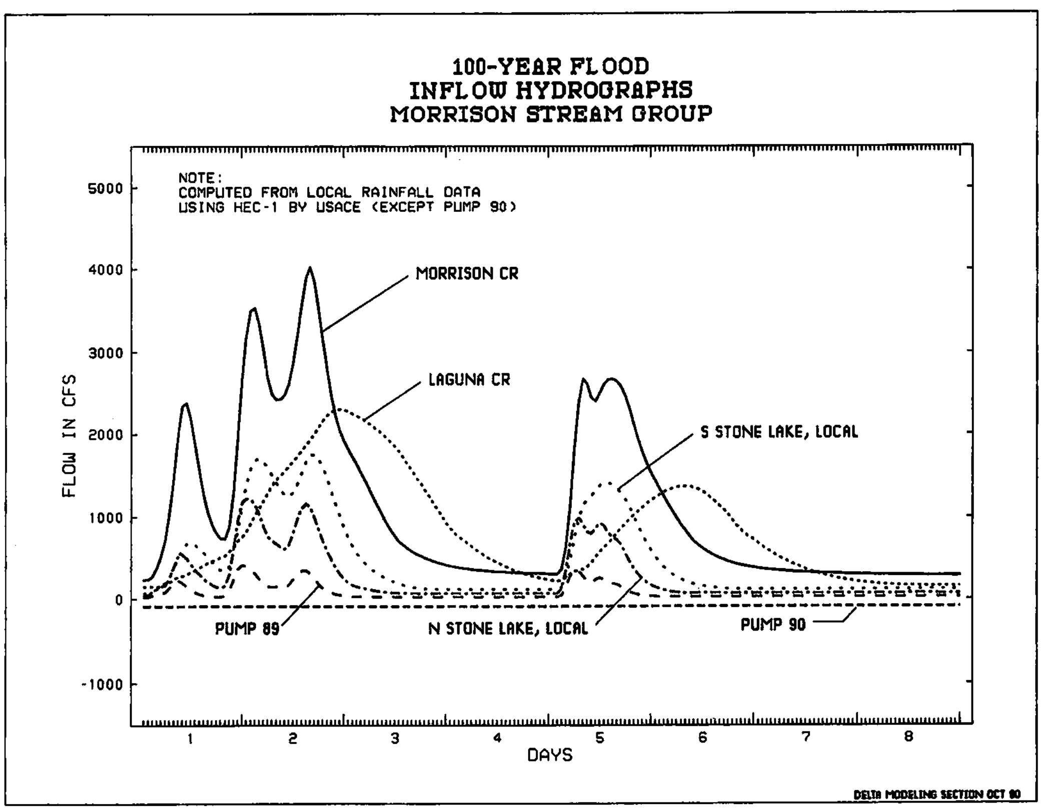


Figure 5-2. 100-Year Flood Hydrographs for the Mokelumne River and Morrison Creek

Table 5-3. Alternative Impacts on 100-Year Flood Stages[1]

Location	No-Action	2A, 2B[2]	3A, 3B	4A, 4B	5A, 5B	6A, 6B
Lambert, north	13.4	12.6	12.3	10.8	10.8	—
Lambert, south	14.8	13.6	13.3	11.7	11.7	< 11.5
Benson's Ferry	18.5	18.1	18.0	14.6	14.6	< 14.5
New Hope Landing	13.4	11.1	10.7	10.5	10.5	< 10.0
South Fork at Hog Slough	8.2	8.6	8.5	8.5	8.5	< 8.0
North Fork at Mid-Staten	9.2	8.4	8.4	8.5	8.6	< 8.0
Junction North & South Forks	7.7	7.7	7.7	7.7	7.7	7.7

[1]Stages are referenced to 0.0' NGVD. Stages are approximate and presented for comparison only.
[2]Stages for Alternatives 2A, 2B,and 6A, 6B are estimated values.

ASSUMPTIONS: Current Lambert Road Hydraulic Structure remains in place.
Current level of development in Morrison Stream Group basins.
McCormack-Williamson Tract and Glanville Tract levees fail.

Slough by as much as 0.3 feet, depending upon the planning scenario selected. This is in part because the model assumes that Little Potato Slough and the South Fork Mokelumne have been combined into one channel connected to the North Fork Mokelumne. It is also partly due to the combined backwater effect from the San Joaquin and the increased flow due to channel enlargement upstream. Any potential stage increase can be eliminated by further refining the upstream and downstream channel enlargement magnitudes.

The modeling results indicate that the preferred alternative can significantly reduce peak flood stages in the north Delta study area for all scenarios considered. They also indicate that if the preferred alternative is implemented, the proposed Lambert Road structure would no longer cause a significant increase in downstream stages (Table 5-2a, column 6 vs. column 7, Table 5-2b, column 3 vs. column 4 and column 7 vs. column 8).

This will greatly reduce the risk of inundating north Delta tracts and islands, which provide for a multitude of beneficial uses, including wildlife habitat.

The duration and areal extent of flooding along the existing channels of the north Delta will also be reduced. This could impact the ecological balance in areas historically subject to inundation, such as the Cosumnes River Preserve area, the Delta Meadows, and the Beach-Stone Lakes area.

The Cosumnes River Preserve area and the Beach-Stone Lakes area have been highly disturbed by the introduction of new species, cattle grazing, diking, irrigated agriculture, and drainage. However, as described in Chapter 4, they retain high wildlife habitat values, and are prime areas for potential wildlife habitat restoration.

Most of the existing riparian forest and wetland areas are associated with the tidally influenced sloughs and tributaries of the Cosumnes River, Dry Creek, the Mokelumne River, Snodgrass Slough, and the Beach—Stone Lakes basin. The reduction in the severity of flooding is not expected to have an adverse impact on those areas which are at elevations close to sea level.

Seasonal wetlands and transition zones at higher elevations may be affected by the reduction in flooding. There are indications that the natural reproductive success of valley oaks, cottonwoods, white alder, and perhaps other riparian vegetation, is closely tied to periodic flooding. Flooding can drown rodents, which feed on seedlings, uproot competing plants, create new, nonvegetated, moist areas for colonization, and transport seeds.

The importance of these processes associated with large scale flooding has not been established and may need further study. The Department is committed to cooperating in the mitigation of any adverse ecological impacts in these areas that may occur as a result of the proposed project and will continue to explore possible mitigation options with the responsible agencies.

Restoration activities in the Cosumnes River Preserve currently includes diking and controlled flooding, extensive tree planting, and weed control. These and other management practices may also be effective in maintaining and enhancing seasonally flooded areas which will receive less frequent and less severe flooding with implementation of the NDP.

Available resource inventories for these areas are summarized in Appendix P.

Other Alternatives

Under alternatives 2A and 2B, the South Fork Mokelumne River would be dredged to a depth of approximately 20 feet. Under alternatives 3A and 3B, both the South and North forks would be dredged. The North Fork is relatively free of sediment, so the conveyance capacity of the system would not be greatly improved as a result of this additional dredging. The impacts of channel dredging under current levels of upstream development and with the existing Lambert Road bridge and under future levels of upstream development and with a new Lambert Road bridge in place have been estimated. The results indicate that channel dredging alone is not sufficient to mitigate for proposed improvements upstream, but would significantly reduce flood stages under current conditions.

Alternatives 6A and 6B involve creation of a floodway through the north Delta to the San Joaquin River by breaching the levees protecting McCormack Williamson Tract, Dead Horse Island, Staten Island, and portions of Bouldin and Brannan-Andrus Island. Only a portion of McCormack-Williamson Tract is above sea level; the rest of the floodway would be permanently inundated. These alternatives were not modeled under flood conditions because it was clear from previous analyses that these alternatives would provide enormous conveyance and storage capacity, thus drastically reducing flooding due to high inflows from upstream watersheds. Stage reductions at New Hope Landing, Benson's Ferry, and the Lambert Road bridge would be significantly greater than under the preferred alternative. In the southern part of the study area, flooding associated with high tides would continue to be a concern.

A comparison of impacts on flood stages of the alternatives under the 100-year flood using Levee Break Scenario 2 is presented in Table 5-3.

These alternatives will also impact the duration and areal extent of flooding, with potential ecological impacts as described under the Preferred Alternative section.

Operation studies and Delta hydrodynamic and water quality studies were used to evaluate potential environmental impacts of the ten north Delta alternatives and the no-action alternative.

These studies provided information for evaluating both the potential environmental impact of the operation of the alternatives as well as the potential environmental impact of the subsequent changes in operation of the Banks Pumping Plant. Monthly water supply studies of the overall SWP and CVP system for the 57-year period 1922 through 1978, with SWP demands assumed at 3.8 MAF, were used to establish the No-action State water supply conditions and Delta hydrologic conditions. A second operation study was made at the same level of SWP demands, which assumed the SDWMP was in place, allowing for a Banks Pumping Plant capacity of 10,300 cfs.

The No-action Delta hydrologic conditions were used in Delta models to establish the No-action Delta hydrodynamic and water quality conditions for five of the water years out of the 57-year study period. These five water years were selected because they contained Delta inflows and diversions representative of those observed for each of the five water year types. This ensured that the No-action Delta hydrodynamic and water quality conditions were determined under a wide range of realistic hydrologic conditions.

The format for discussing operational impacts is explained as follows:

- Background: Information pertinent to the impact under discussion.
- No-action Alternative: A brief review of past, present, and anticipated conditions under the No-action alternative.
- Preferred Alternative: An assessment of incremental impacts based on a comparison with the No-action alternative to quantify impact differences.
- Other alternatives: A similar assessment of incremental impacts compared with the No-action alternative.

Impacts on fish, an important part of this analysis, are generally covered in two parts:

- A qualitative discussion of general impacts, by species, of the effects on migration, survival, and entrainment. Delta inflow and diversions from operational studies, and Delta flows and salinities from Delta modeling, are presented to assess these effects. Fish examined include striped bass, Chinook salmon, sturgeon, American shad, and various resident fishes.

- A quantitative analysis and discussion of direct losses and salvage of screenable–size fish at the Delta Complex, which consists of Banks Pumping Plant, the John E. Skinner Fish Protective Facility, and Clifton Court Forebay.

Direct losses of striped bass and Chinook salmon were estimated on the basis of estimated entrainment losses, including salvage, predation losses, and handling and hauling losses. This method used historic loss data, and SWP diversion records from 1980—1987, to estimate losses that might occur under future SWP diversion rates described in operation studies reflective of the No–action, preferred, and other alternatives assumptions.

Estimated salvage of screenable–size American shad, sturgeon, and resident fish are also presented. This analysis is based on the historical (1968–1980) number of fish salvaged at the screen and assumes that the average population of those fish will remain constant. A lower population value used in the assessment of fish impacts would result in lower fish impacts.

Other operational impacts on the estuarine environment that are evaluated or discussed include aquatic invertebrates and Suisun Marsh.

Monthly Operational Changes

Factors which dictate the monthly operation of the SWP include 1) flood management; 2) electrical load management; 3) flow, exports, and quality measures; 4) natural hydrologic and tidal variations; 5) state water contractors' requests; 6) existing channel configuration; 7) upstream and in–Delta water users; and 8) operational risk analysis.

The CVP has operational constraints similar to those of the SWP listed in the preceding paragraph. CVP diverts water directly from Old River, which affects water conditions in the south Delta and possibly affects SWP operation.

During wet years, SWP storage facilities designated for flood control store flood waters and make controlled releases that reduce or eliminate the potential for flooding in downstream areas. When water surface elevations in the storage facilities encroach into the flood reservation zone, operation of the storage facility is governed by Corps of Engineers (Corps) flood control regulation.

Although the SWP produces a large amount of hydroelectric energy, it consumes even more energy at the various pumping stations located throughout its system. To reduce SWP impacts on the statewide electrical power grid, pumping is conducted during low–demand periods of the day and week to take advantage of the availability and low cost of energy during those periods.

Various protective measures for the Delta have required specific flow and quality measures: 1) Decision 1485 establishes minimum Delta flow, water quality standards, and export limitations to protect fish, municipal, industrial and agricultural uses of the Delta water supply. 2) The Coordinated Operating Agreement (COA) obligates the SWP and the CVP to meet water quality and outflow standards established in Decision 1485 to protect the beneficial uses of the Delta water supply. 3) Agreements and contracts with local Delta interests to provide water users in the Delta with water and water quality standards above the existing Delta standards. 4) A temporary agreement between DWR and DFG to offset direct losses of striped bass, Chinook salmon and steelhead in relation to the Harvey O. Banks Pumping Plant by further limiting export pumping in May and June from 3,000 cfs to no more than 2,000 cfs based on storage withdrawals from SWP facilities upstream of the Delta.

These and other Delta protective measures are discussed in detail in Chapter 1.

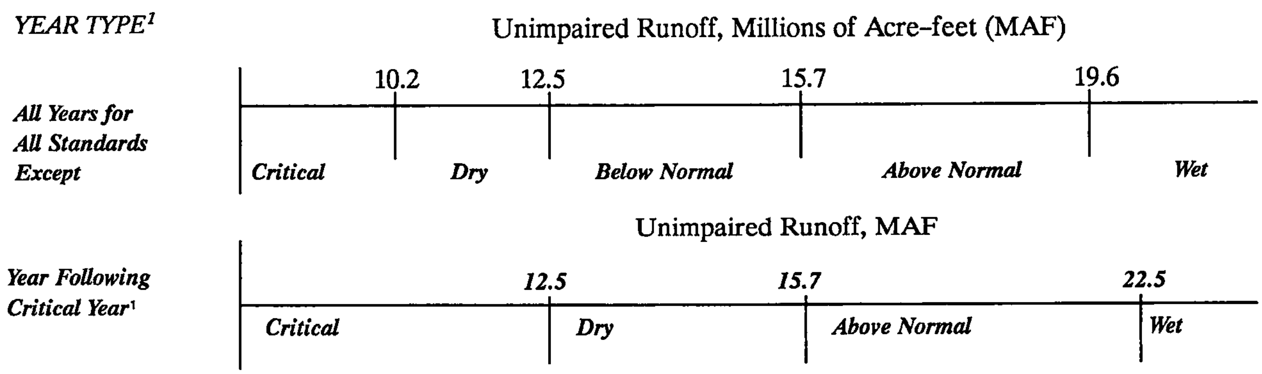
In August 1983, DWR and DFG signed the "Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish and Wildlife." The agreement set releases into the Feather River from Thermalito Diversion Dam for fishery purposes. DWR will continue to operate the SWP under this agreement.

System hydrology helps dictate the amount of SWP diversions throughout the year. Decision 1485 establishes five water–year classifications based on channel hydrology in the Sacramento Valley (Table 5–4). These water year classifications help define water quality standards and the availability and allocation of water to water agencies serviced by the SWP.

The NDP alternatives have been tested under varying monthly export levels, which vary according to the operational considerations listed in Chapter 3. These considerations restrict May, June, and July exports according to D–1485. During high–flow periods, exports are increased; however, monthly average exports exceeding 8,000 cfs occur less than 20 percent of the time. During the spring, average export rates for different years had a range of 2,000

Table 5-4
Decision 1485 Water Year Classification

Year classification shall be determined by the forecast of Sacramento Valley unimpaired runoff for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year) as published in California Department of Water Resources Bulletin 120 for the sum of the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir. Preliminary determinations of year classification shall be made in February, March and April with final determination in May. These preliminary determinations shall be based on hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the water year.



Wet[2]	Equal to or greater than 19.6 MAF (except equal to or greater than 22.5 MAF in a year following a critical year)[3]
Above Normal[2]	Greater than 15.7 MAF and less than 19.6 MAF (except greater than 15.7 MAF and less than 22.5 MAF in a year following a critical year)[3]
Below Normal[2]	Equal to or less than 15.7 MAF and greater than 12.5 MAF (except in a year following a critical year)[3]
Dry[2]	Equal to or less than 12.5 MAF and greater than 10.2 MAF (except equal to or less than 15.7 MAF and greater than 12.5 MAF in a year following a critical year)[3]
Critical[2]	Equal to or less than 10.2 MAF (except equal to or less than 12.5 MAF in a year following a critical year)[3]

[1] *The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.*

[2] *Any otherwise wet, above normal, or below normal year may be designated a subnormal snowmelt year whenever the forecast of April through July unimpaired runoff reported in the May issue of Bulletin 120 is less than 5.9 MAF.*

[3] *"Year following critical year" classification does not apply to Agricultural, Municipal, and Industrial standards.*

cfs, with corresponding variations on impacts to fish. For example, over the 57-year study period, striped-bass losses in May would be reduced by about 5 percent when exports are reduced by 200 cfs. Different levels of export and associated fishery impacts can be determined by comparing monthly operational SWP data to fishery analysis.

Alternative export levels also affect operational flexibility. For example, greater flexibility in operating the SWP can be achieved if maximum daily average SWP exports can periodically reach 10,300 cfs instead of being limited to 6,400 cfs. Current negotiations for fishery protection will consider operational flexibility.

Tidal variations also affect SWP operation. During high tides, diversions into Clifton Court Forebay are usually increased to take advantage of the abundance of water in the Delta channels while still adhering to established water quality requirements.

DWR has contractual agreements with various agencies to deliver water for municipal, industrial, and agricultural uses. Contracted agencies submit their requests to DWR for the upcoming year's water delivery schedule, which depends on water year type, water users request, and the predicted water availability and carryover storage.

Many of the major upstream and in-Delta water users have water right contracts with DWR to request and divert a specified quantity of water. These diversions vary from month to month. At times it is necessary to make additional releases to comply with water quality standards downstream.

Currently, contracts for water delivery requests exceed the firm yield of the SWP. To alleviate the shortfall, SWP operations are determined by present water conditions and by the established acceptable level of risk that balances the quantities of water delivered to contractors this year against the ability of the SWP to fulfill future water deliveries. The SWP operational level of risk is determined by use of the "rule curve," which is discussed in Chapter 1, under "State Water Project Operations."

Operation of the SWP and CVP has affected the seasonal and monthly pattern of Delta inflows, exports, and outflows. Generally, winter and spring inflows and outflows have been decreased, while summer and early fall inflows and outflows have been increased. Upstream of the Delta, the projects and local facilities have altered flow regimes, habitat, and fish populations on the Sacramento, San Joaquin, and Trinity river systems. These past effects are summarized in the final environmental impact report on the Banks Pumping Plant expansion, dated January 1986, and the COA, dated April 1986.

The primary impact of the north Delta alternatives on SWP operations are to reduce carriage water requirements, thereby providing greater operational flexibility. Depending on operational constraints, this results in greater carryover storage for a given level of exports, a higher level of export during periods of limited supply, or combinations of these effects.

The impact of north Delta alternatives on SWP operations was evaluated under two scenarios: In the first, it was assumed that the existing south Delta facilities, in operation or under construction are operational; in the second, it was assumed that the proposed south Delta improvements are also in operation.

Table 5-5 presents the average monthly pumping diversions projected for CVP and SWP in 57-year simulation studies. In order to isolate beneficial or adverse effects of the various alternative actions on the SWP system, CVP operation in all the simulation runs was identical to the no-action alternative. Therefore, CVP average monthly export values given in Table 5-5 under the no-action alternative are applicable to all the other alternatives.

No-action Alternative. Under the no-action alternative most of the pumping will occur during the wet season, from November to April. This is done to minimize pumping diversions in August and September when the ratio of carriage water to pumping diversion is usually at its highest. The 57-year averages of monthly SWP exports during this period range from 4,339 cfs to 6,737 cfs with an average of 6,032 cfs. During the drier part of the year, May to October, the 57-year averages of monthly exports range from 2,094 to 3,903 cfs with an average of 2, 963 cfs.

Preferred Alternative. Under the preferred alternative, the ratio of carriage water to pumping diversion is reduced considerably. Under this condition, shifting the pumping diversions to the latter parts of the year, August and September, and utilizing storage in San Luis Reservoir in the earlier part of the year, May through July, does not penalize the system as much as it would under the no-action alternative. Average monthly pumping diversions during the wet season range from 4,557 cfs to 6,812 cfs with an average of 6,137. During the dry season, the corresponding range is 2,134 cfs to 3,906 cfs with an average of 3,265 cfs.

Table 5–5
Average of Monthly SWP Exports Over 57–Year Study Period (values in cfs)

Month	No–Action CVP (1)	No–Action SWP (2)	2A SWP	2B SWP	3A SWP	3B SWP	4A SWP	4B SWP	5A SWP	5B SWP (3)	6A SWP	6B SWP	Percent Change % (4)
January	4229	6718	6814	6794	6814	6803	6806	6812	6806	6812	6779	6819	1.40
February	4297	6737	6712	6743	6712	6741	6719	6739	6719	6739	6742	6737	0.03
March	4167	5923	5937	5914	5930	5900	5930	5885	5930	5885	5927	5873	–0.64
April	4268	4339	4508	4545	4502	4551	4505	4557	4505	4557	4517	4562	5.02
May	2979	2538	2535	2547	2538	2547	2539	2547	2539	2547	2541	2547	0.35
June	2939	2094	2120	2132	2124	2133	2125	2134	2125	2134	2128	2135	1.91
July	4275	3732	3813	3867	3845	3871	3849	3875	3849	3875	3864	3878	3.83
August	4374	2967	3227	3467	3311	3522	3330	3581	3330	3581	3390	3627	20.69
September	4482	2545	2951	3351	3100	3449	3133	3549	3133	3549	3245	3626	39.45
October	4093	3903	3927	3906	3921	3906	3918	3906	3918	3906	3909	3906	0.08
November	4250	6036	6098	6211	6176	6215	6182	6219	6182	6219	6202	6222	3.03
December	4260	6440	6553	6608	6575	6608	6578	6608	6578	6608	6590	6608	2.61

1) CVP operation is identical in all alternatives.
2) SWP export numbers for all attenatives include wheeling of CVP released water as per the Coordinated Operation Agreement.
3) The Preferred Alternative
4) Difference between the No–Action and the Perferred Alternatives.

Other Alternatives. All other alternatives assume the same Delta inflows and the same maximum export rate as the preferred alternative. The monthly export operation of all the other alternatives, along with the preferred alternative is shown in Table 5–5.

Reverse Flow

A primary objective of the NDP is to reduce reverse flow and related adverse impacts. Reverse flow disorients migratory striped bass, salmon, and steelhead. Reverse flow further increases the impacts on fish by pulling small fish from the west Delta nursery area toward the pumping plants. Reverse flow occurs when the net flow in the west Delta channels is in the upstream direction. It is computed as the sum of the tidally averaged flow in the lower San Joaquin River north of Bradford Island, False River south of Bradford Island, and Dutch Slough west of Taylor Slough (Fig. 5–3).

Pumping by the SWP and CVP in the south Delta are the primary cause of reverse flow. Delta consumptive use for agriculture and pumping by the Contra Costa Water District also contribute to a lesser extent. An inefficient Delta channel system contributes to the reverse flow problem. The massive amount of water driven in and out of the Delta by tidal action (on the order of 200,000 cfs) dwarfs the actual fresh water outflow and considerably complicates the reverse flow analysis.

Water supplies for export by the CVP and the SWP are obtained from surplus Delta flows, when available, and from upstream releases when Delta surplus flows are not available. These surplus flows and releases enter the Delta primarily via the Sacramento River and then flow by various routes to the pumps in the south Delta. Some of these flows are drawn to the pumps through interior Delta channels, facilitated by the Delta Cross Channel. However, because the channels are not large enough, insufficient amounts of water pass through the north Delta channels.

The bulk of the remaining water flows down the Sacramento River to its confluence with the San Joaquin River in the west Delta, then around Sherman Island and back upstream. When fresh water outflow is low, water in the west Delta becomes brackish, because it mixes with saltier sea water entering as tidal inflow and is drawn upstream into the San Joaquin River and other channels by the pumping plants.

To maintain Delta water quality as required by SWRCB Decision 1485, the salt water must be repelled by more Delta outflow. This additional Delta outflow, often provided from reservoir releases, is called "carriage water". (Figure 2–5). A primary benefit of reducing reverse flow is a corresponding reduction in carriage water, which results in greater SWP reliability (see Impacts on SWP Operations)

Reverse flow can be reduced by improving hydraulic conditions in the north Delta, which would encourage more

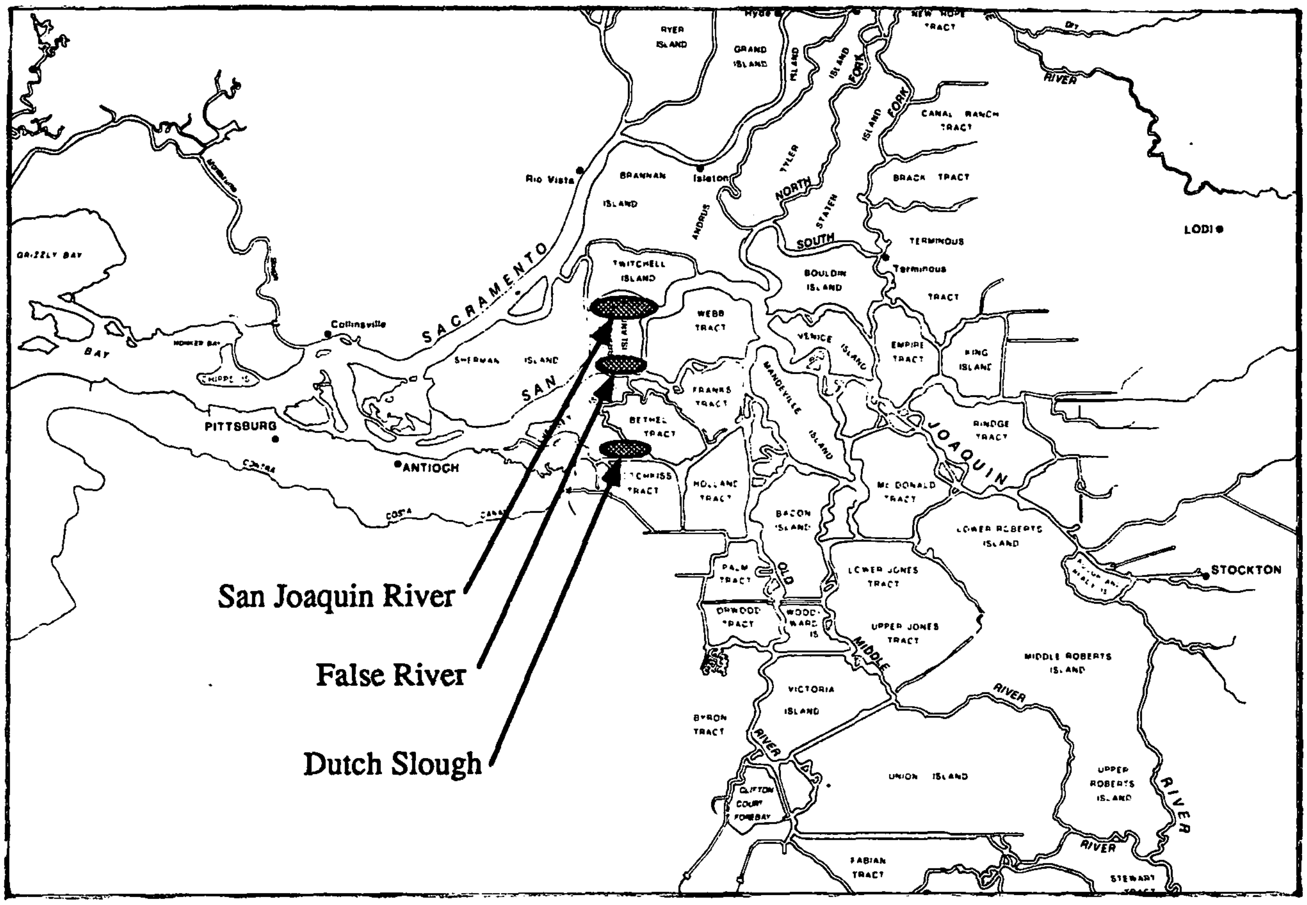


Figure 5–3. Delta Channels Defining Reverse Flow

water to follow the desirable path (Figure 2–6) and make the Delta more efficient. By increasing the flow through the Delta Cross Channel and Georgiana Slough toward the San Joaquin River in the central Delta, reverse flows are reduced in the lower San Joaquin River. Impacts on reverse flow of the various north Delta alternatives were evaluated for five representative year types: wet, above normal, below normal, dry, and critical (Table 5–6). The evaluation was conducted in a three-step modeling process.

First, the DWR/RMA Delta Hydrodynamic model was used to evaluate the impact of the north Delta alternatives on the transfer rate, which defines the proportion of Sacramento River flow entering Georgiana Slough and the Delta Cross Channel. It was assumed that the Delta outflow-salinity relationships described by the Export-Salinity equation (see Supplemental Documentation to Appendix A of the DWR Memorandum report, *Operations Criteria Applied in DWR Planning Simulation Model* (February 1986) were not changed, except that the transfer coefficient associated with each alternative could be substituted for the transfer rate associated with the base case. With the new transfer rate, a set of carriage water curves was derived for each alternative selected for detailed environmental impact analysis.

Second, using the alternative carriage water curves, the SWP simulation program, DWRSIM, was used to simulate operations with a range of north Delta alternatives. These simulations provided monthly simulated data for the 1922–1978 historic data period, including Delta inflows, outflows, consumptive use and exports.

Third, these data, in turn, provided the boundary conditions for operation of the DWRDSM, which was used to simulate monthly average channel flows and salinities in Delta channels for wet, above normal, below normal, dry, and critical years. During the alternative analysis program certain alternatives were dropped from further consideration and remaining alternatives were refined.

In general it was found that reverse flow in the west Delta, as well as other channel flows in the study area varied predictably and smoothly with north Delta channel conveyance capacity. It was thus possible to estimate impacts of

Table 5-6
Total Monthly Average Flows in the San Joaquin River, Dutch Slough, and False River

TOTAL MONTHLY AVERAGE FLOWS IN THE
SAN JOAQUIN RIVER, DUTCH SLOUGH, AND FALSE RIVER
NO SOUTH DELTA FACILITIES

CFS (MINUS SIGN INDICATES REVERSE FLOW)

					REPRESENTATIVE CRITICAL YEAR							
ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	-700	-1300	-2550	-1600	-3000	-3750	-1650	-550	-1500	-900	-900	-1000
2A	400	-200	-1650	-950	-2150	-3100	-1100	100	-835	-600	-500	-950
2B	1700	1300	-500	-300	-1350	-2400	-400	700	-100	50	50	-600
3A	800	250	-1350	-850	-1800	-2950	-950	200	-700	-500	-350	-850
3B	1850	1650	-350	0	-1050	-2050	-150	1000	150	300	300	-400
4A	850	350	-1250	-800	-1750	-2900	-900	250	-650	-400	-300	-850
4B	2000	1900	200	300	-750	-1700	150	1350	400	500	600	-150
5A	850	350	-1250	-800	-1750	-2900	-900	250	-650	-400	-300	-850
5B	2000	1900	-200	-300	-750	-1700	-150	1350	400	500	600	-150
6A	1200	700	-1000	-650	-1500	-2700	-750	400	-500	-300	-200	-800
6B	2100	2100	150	600	-500	-1400	400	1550	500	650	750	150
					REPRESENTATIVE DRY YEAR							
ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	-2240	-1200	-3700	-5200	-3800	-3950	-1700	200	-950	-3900	-1200	-1400
2A	-1860	-100	-3050	-5200	-3000	-3150	-1050	900	-100	-3450	-850	-1250
2B	-1050	-1250	-2150	-5200	-2350	-2200	-100	1800	850	-2250	-400	-1050
3A	-1700	250	-2850	-5200	-2850	-2900	-850	1200	200	-3200	-700	-1200
3B	-800	1450	-1850	-5200	-2100	-1800	0	2000	1000	-2000	-200	-1000
4A	-1650	350	-2800	-5200	-2750	-2800	-800	1300	250	-3100	-650	-1200
4B	-600	1700	-1400	-5200	-1900	-1350	200	2100	1200	-1700	0	-950
5A	-1650	350	-2800	-5200	-2750	-2800	-800	1300	250	-3100	-650	-1200
5B	-600	1700	-1400	-5200	-1900	-1350	200	2100	1200	-1700	0	-950
6A	-1500	650	-2600	-5200	-2600	-2650	-500	1500	450	-2800	-600	-1150
6B	-450	1750	-1150	-5200	-1800	-1000	250	2150	1350	-1550	200	-850
					REPRESENTATIVE BELOW NORMAL YEAR							
ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	-2700	-3400	-1600	-4700	-4450	-7500	-2100	450	-800	-4000	-3250	-1650
2A	-1700	-2350	-600	-4700	-4450	-7500	-800	1150	0	-3000	-2750	-1600
2B	-550	-1050	700	-4700	-4400	-7250	450	2000	900	-1750	-2250	-1500
3A	-1350	-2000	-200	-4700	-4450	-7000	-400	1450	250	-2600	-2550	-1550
3B	-400	-700	850	-4700	-4400	-6850	600	2200	1150	-1450	-2150	-1500
4A	-1300	-1900	-100	-4700	-4400	-7000	-300	1500	300	-2550	-2500	-1550
4B	-200	-400	900	-4700	-4400	-6850	650	2400	1300	-1250	-2050	-1600
5A	-1350	-1900	-100	-4700	-4400	-7000	-300	1500	300	-2550	-2500	-1550
5B	-200	-400	900	-4700	-4400	-6850	650	2400	1300	-1250	-2050	-1600
6A	-1000	-1600	200	-4700	-4400	-7350	100	1700	550	-2300	-2450	-1500
6B	-150	-300	1000	-4700	-4400	-6850	650	2550	1350	-1150	-2050	-1600
					REPRESENTATIVE ABOVE NORMAL YEAR							
ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	-2150	-1450	-1700	-2750	6550	7450	-3600	4850	500	-3450	-4350	-3400
2A	-1200	-350	-750	-2750	6550	7450	-3100	6200	1600	-2450	-3400	-2850
2B	-100	1100	450	-2750	6550	7450	-3100	7900	3000	-1200	-2250	-1900
3A	-850	0	-400	-2750	6550	7450	-3100	6650	2000	-2100	-3100	-2600
3B	50	1450	700	-2750	6550	7450	-3100	8050	3150	-900	-2100	-1650
4A	-800	100	-300	-2750	6550	7450	-3100	6800	2100	-2000	-3000	-2500
4B	100	1700	800	-2750	6550	7450	-3100	8200	3250	-700	-2000	-1500
5A	-800	100	-300	-2750	6550	7450	-3100	6800	2100	-2000	-3000	-2500
5B	100	1700	800	-2750	6550	7450	-3100	8200	3250	-700	-2000	-1500
6A	-550	400	0	-2750	6550	7450	-3100	7200	2400	-1750	-2800	-2300
6B	150	1800	900	-2750	6550	7450	-3100	8300	3350	-500	-1950	-1400
					REPRESENTATIVE WET YEAR							
ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	1050	-650	-2950	1400	7700	12150	10100	2950	3400	-50	-2600	-2150
2A	1350	-175	-2750	5500	8200	12150	10150	3850	4300	900	-1800	-2100
2B	1750	300	-2550	7250	8100	12000	10000	5000	5300	1700	-1150	-1950
3A	1450	0	-2700	6100	8200	12100	10150	4200	4550	1200	-1550	-2050
3B	1900	600	-2500	7750	8100	12000	10000	5200	5600	1950	-1000	-1950
4A	1500	50	-2650	6200	8200	12100	10100	4350	4600	1250	-1500	-2000
4B	2020	700	-2400	8000	8100	12000	10000	5400	5800	2100	-950	-2000
5A	1500	50	-2650	6200	8200	12100	10100	4350	4600	1250	-1500	-2000
5B	2020	700	-2400	8000	8100	12000	10000	5400	5800	2100	-950	-2000
6A	1600	200	-2600	6500	8200	12100	10100	3600	4900	1400	-1350	-2000
6B	2150	750	-2300	8200	8000	12000	10000	5450	5900	2250	-950	-2050

DESCRIPTION OF ALTERNATIVES

1 *No-Action*
2A Dredge So. Frk. Mok.
2B Dredge So. Frk. Mok.,4500sf DXC
3A Dredge NFK, SFK Mok.
3B Dredge NFK, SFK Mok., 4500sf DXC
4A 6-8-10k SFK. Mok., Dredge NFK Mok.
4B 6-8-10k SFK. Mok., Dredge NFK Mok., 4500sf DXC
5A 6-8-14 NFK. Mok.,Dredge SFK. Mok.
5B 6-8-14 NFK. Mok.,Dredge SFK. Mok., 4500sf DXC
6A Staten Island Floodway
6B Staten Island Floodway, 4500sf DXC

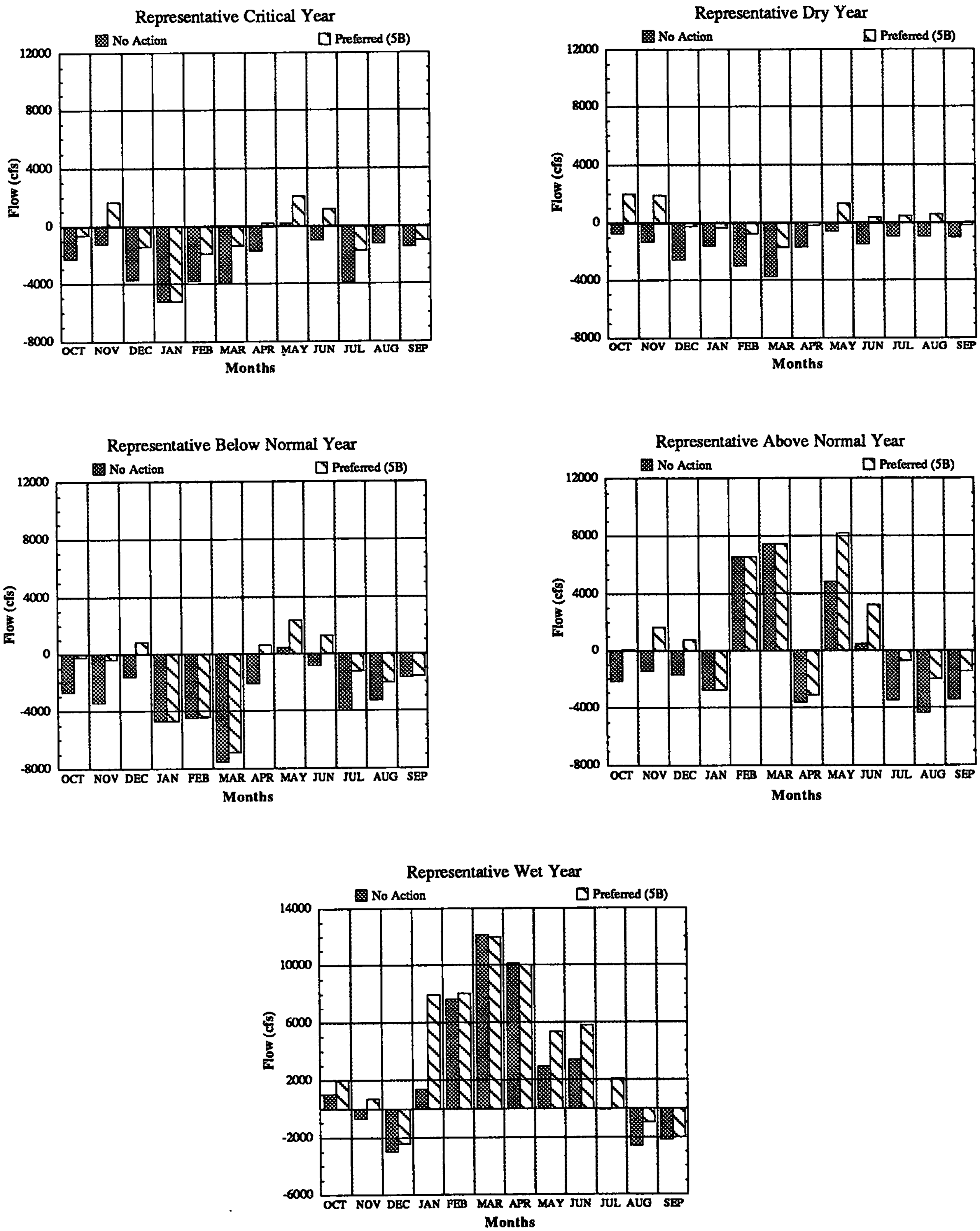


Figure 5–4. Average Monthly Reverse Flow for Representative Year Types

Table 5-7
Reverse Flow Reduction from Base Case Monthly Average (cfs)

Alternative	Representative Year Types				
	Critical	Dry	Below Normal	Above Normal	Wet
1	N/A	N/A	N/A	N/A	N/A
2A	700	600	600	700	800
2B	1,500	1,100	1,400	1,600	1,300
3A	900	800	900	900	900
3B	1,700	1,500	1,500	1,700	1,400
4A	900	800	900	1,000	1,00
4B	2,000	1,800	1,600	1,800	1,500
5A	900	800	900	1,000	1,000
5B	1,900	1,800	1,600	1,800	1,500
6A	1,100	1,000	1,100	1,200	1,000
6B	2,200	1,900	1,700	1,900	1,600

refined alternatives on specific channel flows by interpolation from predictions based upon the original set, for which the three step analysis process had been completed. This interpolation was facilitated by relating a "reverse flow index" to the specific monthly average flows of interest. The model runs show the relative improvements of each alternative compared to the base condition.

The modeling runs have confirmed that an increase in flows through the Delta Cross Channel and through the northeastern sloughs reduce the net reverse flow.

The reverse flow index is the computed reverse flow for a given alternative for a specific, fixed set of river flow and tidal conditions. It was found that monthly reverse flows for different year types varied in proportion to the reverse flow index associated with each alternative. The range of proposed north Delta alternatives will improve the reverse flow situation, but they will not eliminate it completely. During high-outflow periods there will be all positive flow in the lower San Joaquin River, whereas during certain low-flow periods with high project demands there will most likely be some reverse flow with all channel configurations. Any increase in the efficiency of the system will have a continuous benefit in reducing reverse flow.

No-action Alternative. Under the No-action alternative, the reverse flows in the Lower San Joaquin River would be similar to what they are today, because current operations are constrained by SWRCB Decision 1485.

Preferred Alternative. Under the preferred alternative, reverse flow conditions will improve. The average yearly reverse flow for representative year types with the preferred alternative is decreased from the base condition by 1900cfs for the critical year, by 1800 cfs for the dry year, by 1600 cfs for the below normal year, by 1800 cfs for the above normal year, and by 1500 cfs for the wet year. (see Fig. 5-4).

Other Alternatives. If other alternatives would be implemented the reverse flows would also decrease. The range of improvement in average monthly reverse flows for representative year types from the base condition can be seen in Table 5-6. Table 5-7 summarizes the incremental improvement, i.e. reduction, in reverse flow for each representative year type.

State Water Project Reliability

The NDP will increase the reliability of SWP deliveries by:

1) Reducing reverse flow in the lower San Joaquin River, which will improve water quality and allow increased diversions. This will be accomplished by channel improvements of key north Delta channels.

2) Reducing the carriage water required for Delta outflow, thus increasing the amount of water stored in SWP facilities. This will increase the percentage of time during which project demands can be met.

3) Improving the flexibility of seasonal SWP diversions. Improvements in the Mokelumne River and Delta Cross Channel hydraulic capacity would allow for temporary closures of the Delta Cross Channel when concentrations of fish, larvae or eggs are high and for increased diversions from the Sacramento River at less critical times.

4) Improving levees on islands adjacent to channel enlargements. This will decrease the potential for levee failures and salinity intrusion.

SWP's capability for providing water deliveries is determined by the same factors which determine the SWP monthly operational patterns (see "Monthly Operational Changes" in this chapter).

Total annual unimpaired Delta inflows can range from less than 7 MAF to more than 70 MAF. Storage facilities north and south of the Delta help stabilize the annual water supply, but hydraulic constraints and Delta protective criteria restrict diversions. Delta protective standards in Decision 1485, as well as mitigation agreements and other contracts, restrict diversions and reserve surplus water supplies for Delta protection. These factors, which affect the SWP delivery capability, are discussed in greater detail in Chapter 3 under "Operational Considerations."

Table 5-8. Annual SWP Entitlement Water Delivered (Acre-feet)

Year	Requested[1]	Delivered[2]
1967	11,888	56,763
1968	267,000	294,457
1969	248,800	268,104
1970	252,787	369,459
1971	375,590	654,442
1972	820,640	1,031,770
1973	984,700	737,604
1974	1,146,650	878,947
1975	1,311,260	1,230,830
1976	1,488,870	1,380,124
1977	1,660,538	582,381
1978	1,828,624	1,458,733
1979	1,855,003	1,666,457
1980	1,880,386	1,530,256
1981	1,876,707	1,918,563
1982	2,342,576	1,750,680
1983	2,365,818	1,187,156
1984	1,567,520	1,591,416
1985	1,891,849	1,990,279
1986	2,364,193	1,999,155
1987	2,760,920	2,131,608
1988	2,625,328	2,383,570

[1]Requested amounts taken from DWR Bulletin 132 series and do not include requests for surplus water.
[2]Delivered amounts from Table B-5B in Bulletin 132-89.

The operational strategy of SWP reservoirs is also important in determining SWP supplies. SWP facilities operations require a decision of how much water to release in the current year for delivery and how much to store for insurance against unknown subsequent water conditions. There is a trade-off between the level of current deliveries and the acceptable level of risk in case of insufficient future water supplies. Short-range decisions for the operation of SWP facilities are made with an annual "rule curve." The rule curve is further discussed in Chapter 1 under "State Water Project Operations."

The nature of the factors for SWP delivery capability mentioned in the preceding paragraph means that the amount of water the SWP can deliver to its water contractors will vary yearly. Future entitlement requests by water contractors may not always be met, even in non-critical years. Table 5-8 shows the total annual entitlement water requested by water contractors and delivered by SWP from 1967 through 1988. Data for Table 5-8 was extracted from the DWR Bulletin 132 series (*Management of the California State Water Project)*, published annually.

The NDP, discussed at length in Chapter 3 under "Comparison of Physical and Operational Features," will result in more efficient use of available water supplies.

Reducing the amount of water needed in the Delta to maintain proper circulation patterns and adequate water quality increases usable SWP storage upstream of the Delta and will allow: 1) increased flexibility in exporting water, 2) increased water storage in upstream facilities that can be used for recreation or wildlife enhancement, and 3) subsequent use of this water during dry or critical periods. Overall, total annual SWP diversions for each alternative exceed total SWP diversions for the no-action alternative. These diversion increases are dispersed throughout the year. Increasing annual SWP exports usually increases the frequency with which project demands can be met in all water year classifications.

Since SWP deliveries are variable, the reliability of SWP deliveries is always of great importance to SWP water contractors. The reliability of SWP deliveries may be demonstrated by the frequency, duration, and magnitude of deficiencies in deliveries. It may be represented by the frequency with which entitlement requests are met or by the ratio of the volume of delivered water to requested water over an extended study period. Reliability may also be indicated by the average annual SWP delivery over an extended study period or by the SWP delivery during dry periods. However it is examined, the reliability of SWP de-

Table 5–9
Summary of SWP Delivery Capability Analysis

Alternatives	No–action	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B
1. Entitlement Request (excluding losses) TAF/YR	3,703	3,703	3,703	3,703	3,703	3,703	3,703	3,703	3,703	3,703	3,703
2. Number of years entitlement request not met (out of 57 years in study)	44	43	40	41	39	41	39	41	39	41	39
3. Frequency of shortages in SWP deliveries (%)	77	75	70	72	68	72	68	72	68	72	68
4. Average annual dry period supply, TAF/YR	2,211	2,315	2,386	2,345	2,394	2,350	2,398	2,350	2,398	2,365	2,399
5. 57–year average annual delivery, TAF	3,021	3,095	3,153	3,117	3,158	3,130	3,160	3,130	3,160	3,140	3,165
6. Volumetric reliability (%)	82	84	85	84	85	85	85	85	85	85	85

1. Alternative 5B represents the Preferred Alternative.
2. Entitlement request is based on Bulletin 132–88 projections for the 2000 level of development.
3. Frequency of shortage is computed as the number of years entitlement request was not met divided by the study period of 57 years, 1922–1978.
4. Average annual dry period supply is computed as the total deliveries made during the period March 1928 through February 1934, divided by 7 delivery years.
5. Volumetric reliability is computed as the 57–year average divided by the entitlement request.

liveries is directly related to the capability of SWP to deliver water to entitlement holders and to the flexibility with which the SWP can store surplus water over the wet season.

The water supply capability of the SWP has traditionally been expressed in terms of its "firm yield." Firm yield is the dependable annual water supply that can be made available during extended dry periods without exceeding specified allowable reductions in deliveries to agriculture. The firm yield of the SWP is influenced by the same factors that determine SWP delivery capability.

Table 5–9 shows values of other parameters which help describe the reliability of SWP deliveries for each alternative. These values are derived from the operation studies conducted in support of the NDP. The operation studies, discussed in detail in Appendix C, simulate the operation of the SWP during the 57–year study period of 1922 through 1978 under various assumptions.

For all of the alternatives, including the No–action, entitlement requests are 3.8 MAF each year for the 57–year period. Delta inflow, outflow, and diversions comply with Decision 1485 Delta water quality and flow standards and agreements. The monthly average values for the preferred alternative and other alternatives reflect the assumptions of no Los Banos Grandes and no Kern Water Bank, and the capability of SWP to divert 10,300 cfs from the Delta. The operation studies for both the No–action alternative and the preferred and other alternatives use the concept of the 1990 SWP risk delivery curve, developed by the Division of Planning, to establish strategy for SWP operations.

The "Average Annual Dry Period Supply" is generally considered the most realistic expression of the capability of the SWP to deliver water during extended dry periods.The "57–Year Average Annual Delivery" shows the average delivery capability of the SWP under the wide range of hydrologic conditions characteristic of the historical 57–year period of 1922 through 1978.

The parameters mentioned above, as well as others shown in Table 5–9, together indicate the nature of the reliability of each alternative.

No–Action Alternative. Under the no–action alternative, the average annual dry period supply is 2,211 TAF/year. Annual SWP deliveries will fall short of entitlement requests 77 percent of the time. The Volumetric Reliability (total volume of deliveries over the 57–year study period divided by total volume of entitlement request over the same period) is 82 percent.

Preferred Alternative. Under the preferred alternative, the values of all of the indices in Table 5–9 indicate SWP delivery reliability improves compared to the no–action alternative. Dry period deliveries are increased by over 8 percent (approximately 190 TAF/year) compared to the no-action alternative. The 57-year Average Annual Delivery increased by almost 5 percent over the no-action alternative. This is reflected in the 3 percent improvement in Volumetric Reliability of the SWP compared to the no-action alternative.

Other Alternatives. The other alternatives provide water supply reliability improvements in most categories. Improvements in the Average Annual Dry Period Delivery for all of the alternatives range from almost 5 percent to over 8 percent compared to the no-action alternative. Volumetric Reliability is also improved for all of the alternatives (over 2 percent to almost 5 percent). The alternatives that include Delta Cross Channel Gate enlargements consistently provide greater water supply reliability benefits than any of the other alternatives (listed in increasing benefits: 2B, 3B, 4B, 5B (preferred alternative), and 6B). Alternative 6B (Staten Island floodway with Delta Cross Channel Gate enlargement to 4500 sf) provides the greatest benefits to SWP water supply reliability than any of the other alternatives.

Impacts on Delta Outflows

Delta outflow is the water that flows through the Delta and past Chipps Island to San Francisco Bay. Delta outflow averages about 13 MAF per year. The magnitude of this flow is dependent upon Delta inflow, export and depletions of channel water within the Delta. Major Delta inflow consists of the Sacramento River, San Joaquin River, and the Eastside Stream Group. The Sacramento River flow is categorized into the five main water year types as identified in Decision 1485 (wet, above normal, below normal, dry and critical). Delta exports consist of CVP, SWP, North and South Bay Aqueduct, and Contra Costa Canal pumping. Channel depletions occur due to crop irrigation, evaporation, and channel seepage. During normal water years, Delta outflow is higher in winter and spring and decreases during summer and early fall.

Delta outflow consists of fresh water and establishes a hydraulic barrier to prevent salt water from entering deep into the Delta and affecting municipal and agricultural water supplies. This barrier is located in the vicinity of Chipps Island during normal Delta outflow periods. It is here where fresh water meets salt water, called the entrapment zone, that Delta outflows provide a nutrient rich environment for a multitude of organisms that are an integral part of the Bay-Delta food chain. None of the alternatives under consideration will change Delta outflow enough to change the entrapment zone location or characteristics.

No-action Alternative. Delta outflow will vary, depending on project pumping restrictions, water quality standards, and hydrologic conditions in the Delta. The highest outflows will occur during the winter and spring months (December to June). During these months, the average daily outflow is almost 25,500 cfs. The drier months (July to November) have an average outflow of about 6,300 cfs. Monthly Delta outflow ranges from a minimum of about 3,000 cfs during critical years to a maximum of almost 80,000 cfs during wet years. Table 5-10A shows the average monthly Delta outflows for the No-action condition over the 57-year study period.

Preferred Alternative. Substantial improvements are made in the hydraulic efficiency and circulation pattern in the north Delta channels as a result of implementing the preferred alternative. The improved circulation pattern would reduce the reverse flow conditions in the lower San Joaquin River, thereby reducing the amount of Delta outflow required to maintain Delta water quality standards. As a result, the average monthly Delta outflow for the preferred alternative is generally smaller than the no action alternative. For the five water year classifications, about 20 percent of the time monthly Delta outflows are higher than the no action alternative (averaging over 330 cfs higher monthly average flows), and about 32 percent of the time they are equal. Almost 50 percent of the time, monthly Delta outflows would be lower than the no action alternative (averaging over 600 cfs lower).

Lowering the required outflow would increase the storage of fresh water in reservoirs upstream of the Delta. This additional storage could be used to either enhance delivery capability of the SWP, or provide greater flexibility in maintaining water quality standards in the Delta during critical years. Net Delta outflow varies between a minimum of 2500 cfs during critical years and a maximum of 78,000 cfs during wet years. Table 5-10 A shows that about 55 percent of the time, monthly Delta outflows are smaller than the no-action alternative during the low flow months (June through September). The effect of this on the Bay-Delta system is under investigation. Testimonies and exhibits are currently being submitted to the SWRCB Bay- Delta Hearings to determine the possible effects of reduced Delta outflows.

Monthly Average Net Delta Outflows, 1922-1978
No South Delta Alternative
(Values in cubic feet per second)

NO ACTION ALTERNATIVE

Month	CRIT	DRY	BNOR	ANOR	WET	ALL
OCT	6400	5200	7000	4800	7000	6200
NOV	6700	6400	7700	7000	11900	8600
DEC	5600	6600	9700	12500	37100	18200
JAN	5300	10500	11400	15800	78000	33400
FEB	5700	15600	26800	32200	78600	40100
MAR	5000	11600	19000	38100	53200	30500
APR	4800	8400	9100	22900	44400	22600
MAY	4600	7600	9700	16700	32600	17500
JUN	3900	6300	8400	11400	20500	12000
JUL	4200	6200	6900	8300	9900	7600
AUG	3200	3900	5200	6500	7600	5700
SEP	3000	3700	4000	4000	4900	4100

PREFERRED ALTERNATIVE (ALTERNATIVE 5B)

Month	CRIT	DRY	BNOR	ANOR	WET	ALL
OCT	6400	5100	7200	4800	7000	6200
NOV	6200	5600	7800	6600	11800	8200
DEC	4700	6000	9400	12100	38100	18200
JAN	4700	9900	10800	15700	78600	33200
FEB	4900	15000	27200	32900	78800	40100
MAR	4800	11600	19000	38500	53300	30600
APR	4800	8300	9200	22800	44400	22500
MAY	4600	7600	9700	16700	32600	17500
JUN	3900	6300	8400	11400	20500	12000
JUL	4000	5700	7000	8400	9900	7500
AUG	3200	3600	4400	5400	6000	4800
SEP	2500	2700	2500	2800	3700	3000

ALTERNATIVE 2A

Month	CRIT	DRY	BNOR	ANOR	WET	ALL
OCT	6400	5100	7000	4800	6900	6200
NOV	6400	5900	7700	6700	11800	8400
DEC	5100	6200	9500	12300	37700	18200
JAN	5100	10100	11000	15700	78400	33300
FEB	5100	15300	27100	32400	78800	40100
MAR	5000	11500	18900	38400	53300	30500
APR	4800	8400	9200	23000	44300	22600
MAY	4600	7600	9700	16700	32600	17500
JUN	3900	6300	8400	11400	20500	12000
JUL	4000	5600	6900	8400	9900	7500
AUG	3200	3700	4900	6300	7200	5500
SEP	2600	3200	3400	3200	4300	3500

ALTERNATIVE 2B

Month	CRIT	DRY	BNOR	ANOR	WET	ALL
OCT	6400	5100	7100	4800	6900	6200
NOV	6200	5700	7600	6500	11700	8200
DEC	4700	6000	9400	12100	38000	18100
JAN	4900	10000	11000	15800	78800	33000
FEB	4600	15000	27100	32800	78800	40000
MAR	4600	11400	18900	38400	53400	30400
APR	4600	8300	9200	23000	44200	22200
MAY	4600	7600	9700	16700	32600	17500
JUN	3900	6300	8400	11400	20500	12000
JUL	3900	5700	7000	8400	9900	7500
AUG	3100	3700	4600	5800	6500	5100
SEP	2500	2700	2700	2800	3910	3100

ALTERNATIVE 3A

Month	CRIT	DRY	BNOR	ANOR	WET	ALL
OCT	6400	5100	7000	4800	6900	6200
NOV	6300	5900	7600	6600	11700	8300
DEC	4900	6000	9400	12200	37900	18200
JAN	5000	10000	10800	15700	78500	33300
FEB	5000	15200	27100	32600	78800	40100
MAR	4900	11500	18900	38400	53300	30500
APR	4800	8300	9200	22900	44300	22500
MAY	4600	7600	9700	16700	32600	17500
JUN	3900	6300	8400	11400	20500	12000
JUL	4000	5600	7000	8400	9900	7500
AUG	3200	3700	4900	6200	7000	5400
SEP	2600	3000	3100	3100	4200	3400

ALTERNATIVE 3B

Month	CRIT	DRY	BNOR	ANOR	WET	ALL
OCT	6400	5100	7100	4800	6900	6200
NOV	6200	5600	7700	6500	11700	8300
DEC	4700	6000	9500	12100	38100	18200
JAN	4700	9900	10800	15700	78600	33200
FEB	4900	15000	27200	32900	78800	40100
MAR	4800	11600	19000	38500	53300	30600
APR	4800	8300	9200	22800	44400	22500
MAY	4600	7600	9700	16700	32600	17500
JUN	3900	6300	8400	11400	20500	12000
JUL	4000	5700	7000	8400	9900	7500
AUG	3200	3600	4500	5600	6200	4900
SEP	2500	2600	2500	2800	3800	3000

ALTERNATIVE 4A

Month	CRIT	DRY	BNOR	ANOR	WET	ALL
OCT	6400	5100	7000	4800	6900	6200
NOV	6200	5900	7600	6500	11700	8300
DEC	4900	6100	9300	12100	37800	18000
JAN	4900	10000	11000	15800	78800	33000
FEB	4800	15000	27000	32600	78800	40000
MAR	4600	11400	18900	38400	53400	31400
APR	4600	8300	9200	23000	44200	22200
MAY	4600	7600	9700	16700	32600	17500
JUN	3900	6300	8400	11400	20500	12000
JUL	4000	5600	7000	8400	9900	7500
AUG	3100	3700	4800	6100	7000	5300
SEP	2600	3000	3100	3000	4200	3300

ALTERNATIVE 4B

Month	CRIT	DRY	BNOR	ANOR	WET	ALL
OCT	6400	5100	7200	4800	7000	6200
NOV	6200	5600	7800	6600	11800	8200
DEC	4700	6000	9400	12100	38100	18200
JAN	4700	9900	10800	15700	78600	33200
FEB	4900	15000	27200	32900	78800	40100
MAR	4800	11600	19000	38500	53300	30600
APR	4800	8300	9200	22800	44400	22500
MAY	4600	7600	9700	16700	32600	17500
JUN	3900	6300	8400	11400	20500	12000
JUL	4000	5700	7000	8400	9900	7500
AUG	3200	3600	4400	5400	6000	4800
SEP	2500	2700	2500	2800	3700	3000

ALTERNATIVE 5A

Month	CRIT	DRY	BNOR	ANOR	WET	ALL
OCT	6400	5100	7000	4800	6900	6200
NOV	6200	5900	7600	6500	11700	8300
DEC	4900	6100	9300	12100	37800	18000
JAN	4900	10000	11000	15800	78800	33000
FEB	4800	15000	27000	32600	78800	40000
MAR	4600	11400	18900	38400	53400	31400
APR	4600	8300	9200	23000	44200	22200
MAY	4600	7600	9700	16700	32600	17500
JUN	3900	6300	8400	11400	20500	12000
JUL	4000	5600	7000	8400	9900	7500
AUG	3100	3700	4800	6100	7000	5300
SEP	2600	3000	3100	3000	4200	3300

ALTERNATIVE 6A

Month	CRIT	DRY	BNOR	ANOR	WET	ALL
OCT	6400	5100	7100	4800	6900	6200
NOV	6200	5700	7600	6500	11700	8200
DEC	4700	6000	9400	12100	37900	18100
JAN	4900	10000	11000	15800	78800	33000
FEB	4600	15000	27000	32600	78800	40000
MAR	4600	11400	18900	38400	53400	30400
APR	4600	8300	9200	23000	44200	22200
MAY	4600	7600	9700	16700	32600	17500
JUN	3900	6300	8400	11400	20500	12000
JUL	4000	5600	7000	8400	9900	7500
AUG	3100	3700	4800	6000	6800	5200
SEP	2500	2800	2900	2900	4000	3200

ALTERNATIVE 6B

Month	CRIT	DRY	BNOR	ANOR	WET	ALL
OCT	6400	5100	7200	4700	7000	6200
NOV	6100	5500	8000	6600	11800	8400
DEC	4300	6000	9400	12000	38300	18200
JAN	4900	10000	11000	15800	78800	33000
FEB	4400	15000	27200	33000	78800	40000
MAR	4600	11400	18900	38400	53400	30400
APR	4600	8300	9200	23000	44200	22200
MAY	4600	7600	9700	16700	32600	17500
JUN	3900	6300	8400	11400	20500	12000
JUL	3900	5700	7000	8400	9900	7500
AUG	3100	3600	4200	5100	5600	4600
SEP	2500	2500	2500	2700	3600	2800

Other Alternatives. All of the other alternatives provide improved hydraulic efficiency and reduced reverse flow conditions to various degrees. The degree of reverse flow reduction directly correlates to the degree of required Delta outflow reduction. About 17 to 22 percent of the time, monthly Delta outflows for all of the other alternatives are higher than the no-action case. About 23 to 33 percent of the time monthly Delta outflows remain unchanged and between 50 to 57 percent of the time monthly Delta outflow is less than the no-action alternative.

In general, compared to the no-action alternative, all of the alternatives reduce monthly Delta outflow in terms of percent time during low-flow periods, but alternatives with Delta Cross Channel Gate improvements also provide less Delta outflow in terms of flow compared to alternatives without gate improvements (over 17 percent less flow during low-flow months). Modeling results indicate that the Delta Cross Channel Gate improvements is one of the key elements to increase flow into the central Delta which will help reduce reverse flow. In general, reverse flow reduction means less Delta outflow will be required to repel salt water intrusion into the Delta to maintain water quality standards.

Impacts on Delta Outflow Pulses

Delta outflow pulses are flows past Chipps Island that exceed the base flows. Pulses can occur throughout the year but usually occur during late fall and winter due to lower elevation precipitation runoff and in the spring from the Sierra snowmelt and project water releases.

The effects of pulse flows on the Delta and Bay estuary are still not completely understood. The current SWRCB

Bay-Delta Hearings are addressing this interrelationship through testimony presented by public agencies, local entities, and private interest groups.

Delta outflow pulse volumes are classified into four categories:

- between 25,000 cfs and 50,000 cfs
- between 50,000 cfs and 75,000 cfs
- between 75,000 cfs and 100,000 cfs
- over 100,000 cfs

(See Table 5-10 B.)

An outflow pulse is measured from the time when outflow increases sharply on the hydrography curve to the time when the outflow levels off. The flow difference between the high and low positions on the curve is the magnitude of the pulse and is classified into one of the four categories mentioned above.

Duration and frequency are other aspects of outflow pulses that can be impacted. Duration is the length of time the pulse flow occurs. A pulse must occur a minimum of five days to be counted as a pulse flow. Pulse duration and volume are interrelated: the higher the volume, the long-

Table 5-10 B
Comparison of Number of Pulses of Large Delta Outflows, 1955-1978

Condition	Delta Outflow (cfs) 25,000—50,000 avg. of 34,500	50,000—75,000 avg. of 64,000	75,000—100,000 avg. of 96,000	> 100,000 avg. of 188,000
Historical	29	9	9	20
No-action alternative (no south and north Delta improvements; outflows adjusted to reflect 3.8 MAF SWP demands)	29	12	8	16
Preferred Alternative (no south Delta, LBGG, or KWB projects)	29	12	8	16
Other alternatives (no south Delta, LBG, or KWB projects)	29	12	8	16

er the duration time. Frequency is the rate at which a certain flow interval occurs. Historically, smaller pulses tend to have higher frequencies than do large pulses.

Table 5-10 B shows the historical condition, the no-action, and the preferred alternative condition for water years 1955 through 1978. The table categorizes pulses into volume ranges, where in each range the average flows and the number of pulses are identified. The no-action condition corresponds to the "existing facilities" category,whereas the preferred alternative and the other alternatives correspond to the "proposed facilities" category.

No-Action Alternative. Under the no-action alternative, SWP exports will be limited to a maximum of 6,680 cfs daily average diversion. The number of pulses below 25,000 cfs will remain the same compared to the historic condition. Pulses above 50,000 cfs will increase by three while the pulses above 75,000 cfs will decrease by two compared to the historic condition. For Delta outflows above 100,000 cfs, the number of pulses will decrease by four compared to the historic condition. Flow averages do not change significantly for flows below 100,000 cfs, but flow averages decrease by over 4 percent for Delta outflows above 100,000 cfs compared to the historic condition.

Preferred Alternative. Table 5-10 B shows the changes the preferred alternative will have on Delta outflow pulses. Compared to the no-action alternative, the preferred alternative will produce very small changes to the average pulse size for pulses smaller than 50,000 cfs and over 100,000 cfs. For pulses between 50,000 and 100,000 cfs, average pulse size will not change.

Other Alternatives. The impact of all the alternatives on Delta outflow pulses will be approximately the same as that of the preferred alternative.

Impacts on Delta Municipal and Industrial Uses

The water quality of SWP diversions during dry periods can be substantially improved under the NDP. There is also a potential for significant improvements to the water quality of Contra Costa Water District (CCWD) and CVP diversions.

Major diversions from the Delta for municipal and industrial uses, other than the Delta-Mendota Canal (DMC) and California Aqueduct diversions, are the Contra Costa Canal (CCC) intake on Rock Slough, the North Bay Aqueduct intake on Barker Slough, and offshore diversions in the western Delta from Antioch to Crockett.

Decision 1485 municipal and industrial standards for the CCC intake and for Antioch are similar, but they allow use of CCC supplies as a substitute for those at Antioch when offshore water quality is inadequate for the intended use. The 250 mg/l maximum mean daily chlorides must always be met at the CCC intake. Also, a 150 mg/l maximum mean daily chloride standard must also be met for a specified portion of the year, depending on the water year classification. The quality of these supplies is affected by Delta outflow, reverse flow in the lower San Joaquin River, and local agricultural return flow.

DWR has contracts with the city of Antioch, the Fibreboard Corporation, and CCWD that establish formulas for State reimbursement for the additional cost of substitute water from the Contra Costa Canal. The contracts are discussed in Chapter 1 under "Delta Water Contracts."

Appendix C shows projected salinities for various locations during the representative critical, dry, below normal, above normal, and wet years. However, since Delta inflows and exports can vary, monthly salinities of the No-action and the other alternatives can vary substantially.

No-action Alternative. Under the No-action alternative, Decision 1485 municipal and industrial standards would always be met, with the Contra Costa Canal used at times by the City of Antioch.

Preferred Alternative. Under the preferred alternative, water quality conditions at stations for monitoring compliance with Decision 1485 standards would be improved more than by any of the other alternatives considered due to a substantial reduction in reverse flow. Decision 1485 municipal and industrial standards would be met for all years. Water quality conditions at Antioch would be improved in spring and summer months during the representative critical and dry years. In general, under the preferred alternative, the stations in the west Delta for Decision 1485 municipal and industrial standards would experience moderate to substantial improvements in salinity in spring and summer during the representative dry and critical years, and slight to moderate increases in salinity in winter during the representative above-normal and wet years. These trends reflect the difference in Sacramento River flows, Delta exports, and net Delta outflow between the preferred alternative and the No-action alternative.

Dependable water quality in municipal and industrial water supplies is an important component of water supply reliability. The preferred alternative's impacts upon SWP reliability, discussed in Chapter 5 under "SWP Reliability," focused on water volume. However, reliability is also affected by water quality. Because the water quality of SWP diversions is substantially improved during dry and critically-dry periods under the preferred alternative, the reliability of the SWP is improved. Additional work by DWR to protect the State's drinking water supply is discussed in Chapter 6.

Salinity levels in the Delta channels are also important to municipal and industrial water users. Chloride, one of the salts found in Delta water, is monitored and controlled through drinking water standards. Sodium in Delta water is also of health interest because of suspected effects on the human circulatory system.

Bromides, salts that enter the Delta from the ocean, can combine to form cancer-causing chemicals called trihalomethanes (THMs). During the treatment of drinking water, the chlorine used as a disinfectant contacts the naturally occurring dissolved organic chemicals resulting from plant decay. The reaction forms chloroform, a type of THM containing chlorine and carbon. When bromides are also present, these salts enter the chemical reaction, creating THMs that contain bromine in addition to chlorine and carbon.

The bromine-containing THMs present a number of problems in drinking water. Their presence complicates treatment processes because they react differently to treatment methods than does chloroform. Since bromine has twice the molecular weight of chlorine, the presence of bromide-containing THMs increases the difficulty of meeting the weight-based drinking-water standard for THMs. There is also evidence that bromide-containing THMs may be more carcinogenic than chloroform.

The potential of Delta water to form bromide-containing THMs is related to the concentration of bromides in the water and, thus, to the ocean-derived salinity level entering the Delta from the Bay estuary. The concentration ratio of bromide to chloride in sea water is about 1:300. Measurements of Delta water indicate the relationship is similar, thus demonstrating that salinity intrusion from the Bay is a major source of bromides in the Delta.

The preferred alternative will improve water quality (reduce TDS, chloride, and bromide levels), thus reducing the formation of THMs in the south Delta. Figure shows that for the wet water year that followed two critically dry years, and the critically dry water year, the preferred alternative substantially improves TDS levels at the SWP intake gates.

Other Alternatives. Under the other alternatives, water quality at the various Decision 1485 municipal and industrial standards stations would be improved in the same manner as under the preferred alternative. Decision 1485 municipal and industrial standards would be met; however, water quality would generally not be improved as greatly as with the preferred alternative.

Impacts on Delta Agricultural Uses and Water Levels

The NDP will maintain and slightly improve water quality in the north and central Delta for agriculture and will significantly improve water quality reliability.

In the west and interior Delta, agricultural uses of Deltas water supplies can be affected by 1) the varying Delta outflows and the corresponding variations in salinity concentrations, and 2) the buildup of saline agricultural return flows. The NDP alternatives provide for improved circulation of water and a significant reduction in reverse flow.

No-action Alternative. Under the No-action alternative, Decision 1485 agricultural standards would continue to be met, although at the expense of overusing project water supplies. Agricultural concerns in the west Delta would continue to be periodically impacted by high salinity concentrations.

Preferred Alternative. Under the Preferred alternative, water quality will be slightly improved but, more significantly, water quality reliability will be greatly improved.

Other Alternatives. Under the other alternatives, improvements to water quality and reliability will be greater than those for the No-action alternative but not as significant as the improvements under the Preferred alternative.

Impacts on Channel Velocities

In this section, the relative change of channel water velocities produced by the various alternatives are considered and analyzed for channel scour and siltation and for levee erosion potential.

Scour and Siltation. Historically, scouring and silting of Delta channels has occurred due to natural erosion processes, but in recent times these processes have been heavily influenced by and, at times, controlled by other causes. Most of these other causes can be linked to development and improvement in the Delta and upstream areas. Chief factors are levee development, mining, dredging, flood control operation and development, deepwater shipping channel maintenance and enlargement, farming practices, and water routing and diverting.

Less obvious are some of the sediment transport and deposition problems that can result from the construction and operation of large-scale water projects, such as:

- decline of sand supply to coastal beaches;
- deposition in project reservoirs that may reduce the operating flexibility and capacity;
- sediment accumulation at canal bends, siphons, and other structures in the project;
- damage to turbine and pump parts;
- deposition of silts in agricultural irrigation canals;
- water treatment costs;
- navigational impairment;
- recreational impacts; and
- biological changes including fish and wildlife.

Sediment can create major water quality problems. Chemicals, pesticides, bacteria, viruses, radioactive material, and other wastes are assimilated and transported by sediment particles. Turbidity, caused by sediments in water, has resulted in changes in fish species and can therefore impact recreational use. Decreased turbidity due to removal of sediment may stimulate algae and aquatic plant growth.

The sediment load entering the Delta currently varies from 3 to 5 million tons annually. The Sacramento River supplies an estimated 80 to 94 percent of the total, depending on flow conditions. About 80 percent of the annual total is transported in the winter during high flows. Between 10 and 30 percent of the 3 to 5 million tons of sediment is deposited in Delta channels, with about 5 percent entering Clifton Court Forebay and the aqueduct, and the rest entering San Francisco Bay.

The main factors affecting scouring and siltation are water velocity and sediment size, shape, density, and cohesiveness. Since construction of upstream water storage and debris facilities on the major tributaries feeding the Delta, sediment and channel bed material have grown significantly finer. This change has allowed channel velocities to play a more important role in determining scouring and siltation.

The Sacramento River sediment load is carried by the river past the points where the Delta Cross Canal and Georgiana Slough connect with the river. The amounts of sediment transported through these channels can be estimated by using flow relationships modified by the effect of velocity reductions or increases downstream in the Sacramento River and incorporating the effects of peak flow periods.

The average annual measured sediment load of the Sacramento River at Sacramento is about 2.7 million tons (1974). The sediment is exhibiting a decreasing trend which indicates that under the year 2020 projected level of development, the average annual sediment yield will be about 2 million tons. Whether these trends are due to the effect of upstream water resource developments or if the river is still recovering from hydraulic mining in the nineteenth century, or both, cannot be identified.

Sediment is an important consideration when evaluating impacts of increasing or decreasing channel flow or of providing flood flow channel capacity. The NDP has the potential to divert significant portions of the Sacramento River sediment load, roughly in proportion to water diversions. Water diversions will include that which is from an actual increase in diversions and that which replaces all or some of the lower San Joaquin River reverse flow.

Sediment deposition occurs when channel velocities decrease, causing the suspended sediment to be deposited on the channel bed. The alternatives considered include barrier-type facilities in the south Delta to raise water surface elevations upstream, thus increasing water storage in the channels. The barriers may reduce the upstream channel velocities, thus increasing the potential for deposition. There remains a need for further analysis of the potential sediment problems. If trends can be established based on current sediment loadings, then a more definitive statement can be made.

Monthly maximum channel velocities for Snodgrass Slough, Dead Horse Cut, and North and South Fork Mokelumne Rivers have been analyzed from three modeling runs using DWRSIM. The Snodgrass Slough location generally has the highest velocities and so provides the basis for comparing the alternatives (Table 5-11). The table indicates that in most year types velocities do not

Table 5-11
Velocities in Snodgrass Slough Downstream of the Delta Cross Channel

PHASE II MODELING
VELOCITIES IN SNODGRASS SLOUGH DOWNSTREAM OF THE DELTA CROSS CHANNEL
IN FEET PER SECOND

					REPRESENTATIVE CRITICAL YEAR							
ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	1.58	1.61	1.52	1.27	1.51	1.55	1.29	1.22	1.30	1.25	1.14	1.13
2A	1.15	1.16	1.08	0.89	1.01	1.08	0.91	0.85	0.91	0.90	0.79	0.78
2B	1.44	1.44	1.32	1.06	1.02	1.28	1.12	1.07	1.08	1.06	0.94	0.94
3A	1.20	1.20	1.10	0.90	1.05	1.10	0.95	0.85	0.95	0.92	0.82	0.80
3B	1.52	1.58	1.44	1.19	1.34	1.41	1.22	1.14	1.21	1.21	1.06	1.05
4A	1.36	1.23	1.12	0.95	1.06	1.11	0.96	0.86	0.94	0.93	0.83	0.81
4B	1.63	1.72	1.59	1.31	1.50	1.58	1.35	1.30	1.33	1.30	1.18	1.14
5A	1.22	1.23	1.12	0.95	1.06	1.11	0.96	0.86	0.94	0.93	0.83	0.81
5B	1.63	1.72	1.69	1.31	1.50	1.58	1.35	1.30	1.33	1.30	1.18	1.14
6A	1.30	1.31	1.18	0.94	1.10	1.15	1.00	0.89	0.97	0.96	0.85	0.84
6B	1.70	1.82	1.66	1.40	1.58	1.68	1.40	1.40	1.40	1.35	1.25	1.23
					REPRESENTATIVE DRY YEAR							
ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	1.37	1.64	1.52	0.36	1.57	1.58	1.48	1.37	1.40	1.60	1.23	1.22
2A	0.97	1.19	1.05	0.20	1.09	1.11	1.06	0.97	0.98	1.14	0.86	0.86
2B	0.17	1.46	1.24	0.18	1.29	1.24	1.20	1.15	1.95	1.39	1.08	1.05
3A	1.00	1.20	1.03	0.18	1.13	1.09	1.05	1.00	1.01	1.16	0.87	0.80
3B	1.29	1.59	1.39	0.20	1.43	1.48	1.44	1.29	1.31	1.53	1.20	1.15
4A	1.00	1.20	1.05	0.17	1.14	1.10	1.06	1.03	1.04	1.20	0.89	0.90
4B	1.20	1.81	1.52	0.21	1.49	1.65	1.60	1.37	1.40	1.62	1.30	1.27
5A	1.00	1.20	1.05	0.17	1.14	1.10	1.06	1.03	1.04	1.20	0.89	0.90
5B	1.20	1.85	1.52	0.21	1.49	1.65	1.60	1.37	1.40	1.62	1.30	1.27
6A	1.06	1.20	1.10	0.15	1.20	1.18	1.15	1.07	1.08	1.25	0.95	0.95
6B	1.48	1.40	1.62	0.24	1.56	1.77	1.72	1.45	1.50	1.73	1.41	1.36
					REPRESENTATIVE BELOW NORMAL YEAR							
ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	1.53	1.54	1.57	0.31	0.34	0.31	1.49	1.35	1.45	1.63	1.55	1.29
2A	1.10	1.11	1.13	0.18	0.19	0.18	1.04	0.95	1.02	1.16	1.10	0.90
2B	1.36	1.36	1.40	0.14	0.14	0.12	1.24	1.12	1.20	1.40	1.33	1.06
3A	1.09	1.11	1.11	0.11	0.13	0.12	1.00	0.98	1.00	1.15	1.07	0.88
3B	1.45	1.51	1.50	0.18	0.19	0.18	1.36	1.27	1.37	1.56	1.50	1.22
4A	1.10	1.13	1.11	0.10	0.12	0.11	1.00	0.99	1.00	1.15	1.06	0.90
4B	1.50	1.68	1.56	0.20	0.02	0.20	1.40	1.43	1.40	1.68	1.60	1.30
5A	1.10	1.13	1.11	0.10	0.12	0.11	1.00	0.99	1.00	1.15	1.06	0.90
5B	1.50	1.68	1.56	0.20	0.02	0.20	1.40	1.43	1.40	1.69	1.63	1.30
6A	1.15	1.19	1.20	0.10	0.11	0.10	1.03	1.00	1.02	1.20	1.10	0.94
6B	1.50	1.80	1.57	0.20	0.28	0.20	1.37	1.56	1.39	1.70	1.64	1.38
					REPRESENTATIVE ABOVE NORMAL YEAR							
ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	1.48	1.59	1.57	0.31	0.59	0.75	0.39	1.90	1.60	1.64	1.66	1.46
2A	1.06	1.15	1.13	0.18	0.31	0.43	0.21	1.37	1.20	1.18	1.19	1.04
2B	1.03	1.40	1.40	0.10	0.25	0.30	0.20	1.60	1.40	1.40	1.40	1.20
3A	1.05	1.10	1.10	0.10	0.20	0.30	0.20	1.30	1.10	1.10	1.20	1.10
3B	1.40	1.56	1.50	0.18	0.32	0.43	0.20	1.70	1.54	1.58	1.56	1.38
4A	1.06	1.10	1.10	0.10	0.20	0.30	0.10	1.30	1.10	1.10	1.20	1.10
4B	1.47	1.60	1.60	0.20	0.40	0.50	0.20	1.70	1.60	1.60	1.60	1.50
5A	1.06	1.10	1.10	0.10	0.20	0.30	0.10	1.30	1.10	1.10	1.20	1.10
5B	1.47	1.60	1.60	0.20	0.40	0.50	0.20	1.70	1.60	1.60	1.60	1.50
6A	1.10	1.20	1.20	0.10	0.20	0.30	0.10	1.40	1.10	1.10	1.20	1.10
6B	1.50	1.60	1.60	0.30	0.40	0.60	0.20	1.70	1.60	1.70	1.70	1.60
					REPRESENTATIVE WET YEAR							
ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	0.92	1.10	1.44	0.46	0.39	0.42	0.42	1.51	1.51	1.54	1.56	1.38
2A	0.60	0.73	1.02	0.26	0.22	0.24	0.24	1.10	1.08	1.09	1.09	0.97
2B	0.80	0.90	1.20	0.20	0.20	0.20	0.20	1.30	1.20	1.30	1.30	1.20
3A	0.70	0.70	1.00	0.20	0.20	0.20	0.20	1.20	1.10	1.10	1.10	1.00
3B	0.74	0.99	1.40	0.26	0.22	0.24	0.24	1.45	1.45	1.48	1.45	1.32
4A	0.70	0.70	1.00	0.20	0.20	0.20	0.20	1.20	1.10	1.10	1.10	1.00
4B	0.70	1.00	1.40	0.30	0.30	0.30	0.30	1.50	1.50	1.60	1.50	1.40
5A	0.70	0.70	1.00	0.20	0.20	0.20	0.20	1.20	1.10	1.10	1.10	1.00
5B	0.70	1.00	1.40	0.30	0.30	0.30	0.30	1.50	1.50	1.60	1.50	1.40
6A	0.70	0.70	1.00	0.20	0.20	0.20	0.20	1.20	1.20	1.20	1.20	1.00
6B	0.60	1.00	1.40	0.30	0.30	0.30	0.30	1.50	1.50	1.70	1.60	1.40

DESCRIPTION OF ALTERNATIVES

1	No-Action	4A	6-8-10k SFK. Mok., Dredge NFK Mok.
2A	Dredge So. Frk. Mok.	4B	6-8-10k SFK. Mok., Dredge NFK Mok., 4500sf DXC
2B	Dredge So. Frk. Mok.,4500sf DXC	5A	6-8-14 NFK. Mok.,Dredge SFK. Mok.
3A	Dredge NFK, SFK Mok.	5B	6-8-14 NFK. Mok.,Dredge SFK. Mok., 4500sf DXC
3B	Dredge NFK, SFK Mok., 4500sf DXC	6A	Staten Island Floodway
		6B	Staten Island Floodway, 4500sf DXC

change significantly and that average channel velocities are well below scour velocities of 3 feet per second.

No Action Alternative. Scour and siltation processes will continue with no significant changes.

Preferred Alternative. In most months of the 5 representative year types, average channel velocities are reduced slightly. There will probably not be a significant change in current scour patterns. There may be a slight increase in sediment load in the north Delta channels due to higher rates of diversion through the Delta Cross Channel. However, the diversions occur when Sacramento River flows are below 30,000 cfs, when sediment loads are relatively low.

Other Alternatives. Channel velocities (Table 5-11) and scour patterns will not change significantly. All the alternatives will result in higher diversions through the Delta Cross Channel and thus will add somewhat to the sediment load carried into the north Delta channels. Deposition is expected to be greatest with Alternatives 6A and 6B, which create a large open body of water with small net velocities.

Levee Erosion. Flows in the north Delta are not high enough to significantly harm levees. Field tests indicate that channel erosion will likely occur in the Delta when the flow is greater than 3 fps. Table 5-11 shows that the maximum channel velocities downstream of the Delta Cross Channel do not exceed 3 fps. This is because during high flows, when Sacramento River flow is greater than 30,000 cfs, the Cross Channel gates are closed, reducing the flow entering the north Delta channels. This is evident in Table 5-11, which shows that velocities are significantly reduced during the high-flow period of January through May, when the gates are normally closed.

Levee erosion due to right angle flows has been identified at two locations. On Staten Island, the levee at the south end of Dead Horse Cut receives perpendicular flow from Dead Horse Cut and has required extensive rock protection.

On McCormack-Williamson Tract, the levee at the confluence of the Delta Cross Channel and Snodgrass Slough has recently been stripped of vegetation and rock protection emplaced due to erosion possibly caused by incoming flows and wave action from the Delta Cross Channel.

Impacts on Cross-Delta Flows

Changes in cross-Delta flows for the alternative operational plans have been evaluated. Increased flows in the Delta Cross Channel (Reclamation facility) and in Georgiana Slough are related primarily to Sacramento River inflows and are therefore affected by upstream releases and natural flow conditions.

The operation of the Delta Cross Channel gates is dictated by Decision 1485 restrictions to protect salmon and striped bass. For all the alternatives, gate operations remain the same. From January 1 to April 15, the Delta Cross Channel gates are closed whenever the daily Delta outflow exceeds 12,000 cfs. From April 16 to May 31, the Delta Cross Channel gates are closed for no more than two of four consecutive days for up to 20 total days, based on input from DFG. The gates also are closed when Sacramento River flow at the I Street Bridge in Sacramento is greater than 30,000 cfs. Otherwise, the gates remain open except for testing.

The efficiency of the Delta Cross Channel in diverting Sacramento River flow to the central Delta is expressed by a value called the "transfer coefficient" (Table 5-12 lists the transfer coefficients for each alternative and for all water year classifications). The transfer coefficient is the Delta Cross Channel flow plus the Georgiana Slough flow divided by the Sacramento River flow at the I Street bridge. The higher the value, the more efficiently the Delta Cross Channel diverts Sacramento River flow into the interior Delta.

Table 5-12 shows the ratio of cross-Delta flows to Sacramento River flows for five representative water years. Each water year in Table 5-12 represents an actual water year that most closely resembles one of the five main water year types.

Table 5-12 shows that during January through April for below- normal, above-normal, and wet years, the transfer coefficient is much lower than during other months. During these months, the Delta Cross Channel gates are

Table 5-12*
Ratio of Delta Cross-Channel and Georgiana Slough Flows to Sacramento River Flows**

Representative Critical Year

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No-Action	0.33	0.36	0.38	0.46	0.41	0.40	0.45	0.45	0.44	0.45	0.48	0.48
2A	0.38	0.40	0.44	0.52	0.49	0.47	0.50	0.51	0.50	0.50	0.54	0.55
2B	0.45	0.46	0.51	0.58	0.56	0.54	0.57	0.57	0.57	0.57	0.61	0.62
3A	0.40	0.42	0.46	0.54	0.51	0.49	0.52	0.53	0.52	0.52	0.56	0.57
3B	0.45	0.47	0.52	0.61	0.58	0.56	0.59	0.60	0.59	0.59	0.63	0.64
4A	0.40	0.42	0.46	0.54	0.51	0.49	0.53	0.53	0.52	0.52	0.56	0.57
4B	0.46	0.48	0.53	0.63	0.60	0.58	0.61	0.61	0.61	0.61	0.66	0.66
5A	0.40	0.42	0.46	0.54	0.51	0.49	0.53	0.53	0.52	0.52	0.56	0.57
5B ***	0.46	0.48	0.53	0.63	0.60	0.58	0.61	0.61	0.61	0.61	0.66	0.66
6A	0.42	0.44	0.48	0.55	0.53	0.51	0.54	0.55	0.54	0.54	0.56	0.59
6B	0.46	0.49	0.55	0.64	0.61	0.60	0.62	0.63	0.63	0.62	0.68	0.68

Representative Dry Year

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No-Action	0.43	0.34	0.41	0.15	0.39	0.39	0.39	0.40	0.41	0.38	0.46	0.46
2A	0.50	0.39	0.48	0.15	0.46	0.45	0.44	0.46	0.47	0.44	0.52	0.53
2B	0.56	0.45	0.55	0.15	0.54	0.52	0.51	0.52	0.53	0.51	0.58	0.60
3A	0.51	0.40	0.50	0.15	0.48	0.47	0.46	0.48	0.48	0.46	0.53	0.55
3B	0.58	0.46	0.57	0.15	0.56	0.54	0.52	0.54	0.55	0.52	0.60	0.62
4A	0.52	0.41	0.50	0.15	0.49	0.47	0.47	0.49	0.49	0.46	0.54	0.56
4B	0.60	0.47	0.59	0.15	0.57	0.56	0.54	0.56	0.57	0.53	0.63	0.64
5A	0.52	0.41	0.50	0.15	0.49	0.47	0.47	0.49	0.49	0.46	0.54	0.56
5B ***	0.60	0.47	0.59	0.15	0.57	0.56	0.54	0.56	0.57	0.53	0.63	0.64
6A	0.54	0.42	0.52	0.15	0.50	0.50	0.48	0.50	0.50	0.48	0.55	0.57
6B	0.62	0.47	0.60	0.15	0.59	0.57	0.55	0.57	0.58	0.55	0.63	0.66

Representative Below Normal Year

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No-Action	0.36	0.40	0.35	0.15	0.15	0.15	0.38	0.41	0.40	0.37	0.39	0.45
2A	0.42	0.45	0.40	0.15	0.15	0.15	0.44	0.47	0.46	0.43	0.45	0.51
2B	0.49	0.50	0.47	0.15	0.15	0.15	0.52	0.53	0.53	0.49	0.52	0.58
3A	0.43	0.46	0.42	0.15	0.15	0.15	0.46	0.48	0.48	0.44	0.47	0.53
3B	0.49	0.50	0.47	0.16	0.15	0.15	0.52	0.53	0.53	0.49	0.52	0.59
4A	0.44	0.47	0.42	0.15	0.15	0.15	0.47	0.49	0.48	0.44	0.47	0.54
4B	0.50	0.53	0.48	0.16	0.16	0.15	0.54	0.57	0.56	0.52	0.55	0.64
5A	0.44	0.47	0.42	0.15	0.15	0.15	0.47	0.49	0.48	0.44	0.47	0.54
5B ***	0.50	0.53	0.48	0.16	0.16	0.15	0.54	0.57	0.56	0.52	0.55	0.64
6A	0.45	0.48	0.44	0.15	0.15	0.15	0.49	0.50	0.50	0.46	0.49	0.55
6B	0.51	0.54	0.49	0.16	0.16	0.15	0.55	0.58	0.58	0.53	0.56	0.66

Table 5-12* (Continued)
Ratio of Delta Cross-Channel and Georgiana Slough Flows to Sacramento River Flows**

Representative Above Normal Year

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No-Action	0.37	0.36	0.36	0.16	0.13	0.12	0.14	0.30	0.32	0.36	0.37	0.39
2A	0.43	0.41	0.41	0.16	0.13	0.12	0.14	0.34	0.37	0.41	0.42	0.45
2B	0.50	0.47	0.48	0.16	0.13	0.12	0.15	0.39	0.44	0.48	0.49	0.52
3A	0.45	0.43	0.43	0.16	0.13	0.12	0.15	0.35	0.39	0.43	0.44	0.47
3B	0.50	0.48	0.49	0.16	0.13	0.12	0.15	0.39	0.44	0.49	0.51	0.53
4A	0.45	0.43	0.44	0.16	0.13	0.12	0.15	0.36	0.39	0.43	0.45	0.48
4B	0.51	0.48	0.50	0.16	0.13	0.13	0.15	0.40	0.44	0.50	0.53	0.54
5A	0.45	0.43	0.44	0.16	0.13	0.12	0.15	0.36	0.39	0.43	0.45	0.48
5B ***	0.51	0.48	0.50	0.16	0.13	0.13	0.15	0.40	0.44	0.50	0.53	0.54
6A	0.47	0.45	0.45	0.16	0.13	0.12	0.15	0.37	0.41	0.45	0.46	0.49
6B	0.52	0.49	0.51	0.16	0.13	0.13	0.15	0.40	0.45	0.52	0.55	0.56

Representative Wet Year

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No-Action	0.53	0.50	0.42	0.14	0.13	0.13	0.13	0.35	0.36	0.37	0.39	0.43
2A	0.58	0.56	0.48	0.14	0.13	0.13	0.13	0.40	0.41	0.43	0.45	0.50
2B	0.64	0.62	0.55	0.14	0.13	0.13	0.13	0.46	0.47	0.49	0.52	0.57
3A	0.60	0.57	0.50	0.14	0.13	0.13	0.13	0.41	0.42	0.44	0.47	0.51
3B	0.67	0.65	0.58	0.14	0.13	0.13	0.13	0.47	0.48	0.50	0.54	0.59
4A	0.60	0.58	0.50	0.14	0.13	0.13	0.13	0.42	0.43	0.44	0.47	0.52
4B	0.69	0.68	0.59	0.14	0.13	0.13	0.13	0.48	0.49	0.52	0.56	0.61
5A	0.60	0.58	0.50	0.14	0.13	0.13	0.13	0.42	0.43	0.44	0.47	0.52
5B ***	0.69	0.68	0.59	0.14	0.13	0.13	0.13	0.48	0.49	0.52	0.56	0.61
6A	0.61	0.59	0.52	0.14	0.13	0.13	0.13	0.43	0.44	0.46	0.48	0.54
6B	0.73	0.70	0.61	0.14	0.13	0.13	0.13	0.48	0.51	0.53	0.58	0.63

* Table C-11 in Appendix C provides flow data used to calculate the ratios.

** Ratios are calculated by using the monthly average flows for Georgiana Slough, Delta Cross Channel, and Sacramento River as input into the following formula:

$$\text{Ratio} = \frac{\text{Georgiana Slough Q} + \text{Delta Cross Channel Q}}{\text{Sacramento River Q}}$$

*** Alternative 5B represents the Preferred Alternative.

closed in accordance with Decision 1485, and the cross-Delta flow (Delta Cross-Channel flow plus Georgiana Slough flow) is reduced to only the Georgiana Slough flow, which significantly reduces the transfer coefficient.

No-Action Alternative. For the representative wet year, the transfer coefficient ranges from 0.13 to 0.53. The highest monthly transfer coefficients occur during the end of summer and fall periods when Sacramento River flow is at its lowest. For the representative critically dry year, the transfer coefficient ranges from 0.33 to 0.48. During critically dry years, the Delta Cross Channel gates remain open throughout the year maintaining a more constant transfer coefficient average.

Preferred Alternative. The preferred alternative will significantly increase Sacramento River diversions into the central Delta. Except for those months when the Delta Cross Channel gates are closed, the preferred alternative increases the transfer coefficient by 0.1 to 0.19 compared to the no-action alternative with an overall average increase of over 0.15. This equates to an average of about 38 percent increase in Sacramento River diversion efficiency. Increased Sacramento River diversions into the central Delta will help reduce the effects of reverse flow by increasing San Joaquin River flow. Reduction of reverse flows impede salt water intrusion into the Delta, thus improving Delta water quality. Improvements in the transfer coefficient remains fairly consistent through all the representative water year classifications.

Other Alternatives. All of the other alternatives show higher transfer coefficients compared to the no-action alternative. Alternative 2A shows the smallest increase in transfer coefficient (average of about 15 percent over the no-action alternative) while Alternative 6B shows the greatest increase (average of about 40 percent increase over the no-action alternative). All of the alternatives that include Delta Cross Channel Gate improvements show significant increases in the transfer coefficient (average of about 15 percent) compared to similar alternatives that do not include Gate improvements. This indicates that the Delta Cross Channel Gate improvements is one of the key components to increasing Sacramento River diversions into the central Delta to help reduce reverse flow and improve water quality.

General Impacts on Salmon and Steelhead

Chinook salmon (*Oncorhynchus tshawytscha*) is the principal salmonid using the Sacramento-San Joaquin estuary. Chinook salmon produced in Central Valley streams are a valuable commercial and sport fisheries resource, making up the majority of ocean salmon catches in California and contributing significantly to ocean salmon fisheries along the coasts of Oregon and Washington. During 1977 through 1986, the contribution of Central Valley salmon stocks to California sport and commercial ocean harvest averaged approximately 400,000 fish.

Steelhead trout (*Oncorhynchus mykiss*) are an anadromous form of rainbow trout. They are a highly prized sport fish taken by anglers during the spawning runs in the main stem Sacramento River and its tributaries.

Central Valley chinook salmon have an anadromous life cycle (Figure 5-5), spending most of their adult life in the ocean but migrating up Central Valley rivers and streams to spawn. Within the Sacramento-San Joaquin drainage there are several distinct populations (usually referred to as "runs") of salmon. Although there is some natural and man-induced straying, the native runs within each river and stream are generally distinct from the runs in other rivers. Some Central Valley streams support multiple runs, which make their upstream spawning migrations at different times of the year. Figure 5-6 generally describes the timing of the life history elements of the salmon runs, named for the time of year adults enter fresh water on their spawning migration. After these salmon construct a nest (redd) and females deposit the fertilized eggs, they die in the stream of their origin.

The life history of Central Valley steelhead is similar to that of chinook salmon with a couple of major differences. Unlike chinook salmon, which inevitably die after spawning, steelhead may live to return to the ocean and perhaps spawn again. Also, juvenile steelhead generally remain in fresh water for 1 to 3 years before emigrating to the ocean. The run of steelhead into Central Valley streams is drawn out but continuous, extending from July to February,

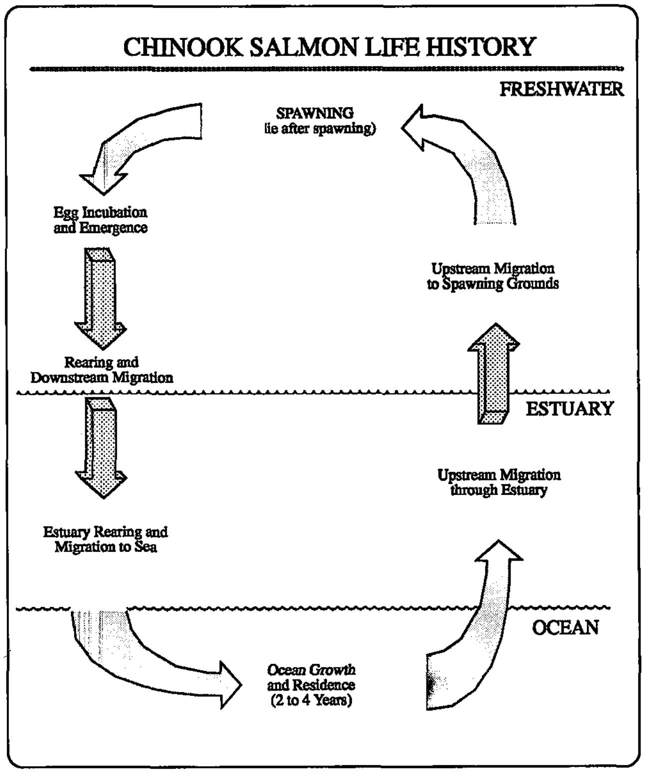


Figure 5-5. Chinook Salmon Life History

peaking in October and November. Like chinook salmon, steelhead generally return to spawn in the stream where they reared.

All Central Valley stocks of chinook salmon and steelhead are potentially affected by the NDP because the Program influences conditions in the Delta, through which these fish must pass during their migrations to and from the upstream spawning and rearing grounds. In addition, the NDP would change the water release schedule from Oroville Reservoir, which may affect spawning, incubation, and rearing conditions in the Feather and lower Sacramento Rivers.

Because each of the Central Valley chinook salmon runs has somewhat different environmental requirements and is likely to be affected differently by the NDP, a separate description of important runs and NDP effects is provided below.

Sacramento River Drainage Stocks. The Sacramento River drainage presently produces approximately 90 percent of all Central Valley chinook salmon and virtually all of its steelhead. Spawning occurs in all of the major tributaries to which salmon still have access (American, Feather, Bear, and Yuba rivers), the main stem of the Sacramento River below Keswick Dam, and in many smaller tributaries. Sacramento River drainage stocks are the subject of intense management efforts mainly directed at controlling harvest and overcoming the negative effects of water development, land use changes, and poor water quality in the drainage. Most of this effort, which includes complex fishing regulations, three major hatcheries, diversion screens, fish ladders, and instream flow and temperature requirements, is focused outside the Delta. All four seasonal runs of chinook salmon use the drainage.

Two of the four runs, fall and winter, are of particular importance in evaluating the impacts of the NDP. Fall-run Sacramento River drainage salmon are important because they are the largest of the four runs, accounting for roughly 80 percent of total Central Valley salmon production. Winter-run salmon are important because recent severe declines in their abundance have led to their classification as an endangered species by California's Fish and Game Commission and as a threatened species by the National Marine Fisheries Service (NMFS).

Fall-run Chinook Salmon. Fall-run adults enter the Delta on their upstream migration primarily during September through November using the scent of their natal stream to guide them to the spawning grounds. Their migration through the Delta is presently relatively unimpeded by human activities, although the diversion of Sacramento River water through the Delta Cross Channel and Georgiana Slough into the Central Delta may cause some fish to stray temporarily into the lower San Joaquin and Mokelumne River systems, possibly delaying their migration.

Fall-run salmon spawn above the Delta in late fall and winter in the main stem Sacramento River and many of its tributaries. Although access to much of the historically used spawning habitat has been eliminated by the construction of dams and the diversion of water, successful natural spawning still occurs in the rivers where appropriate temperature, flow, and gravel substrate conditions exist. In addition to the natural spawning some adult fish enter hatcheries on the American River, Feather River, and Battle Creek, where they are artificially spawned and their offspring reared.

Juvenile fall-run salmon emerge from the gravel in late winter and begin the process of rearing and downstream migration. There is considerable variation, both annually and among individuals, in the timing of downstream migration and location of rearing, apparently related to river flow conditions following emergence. Generally, if late

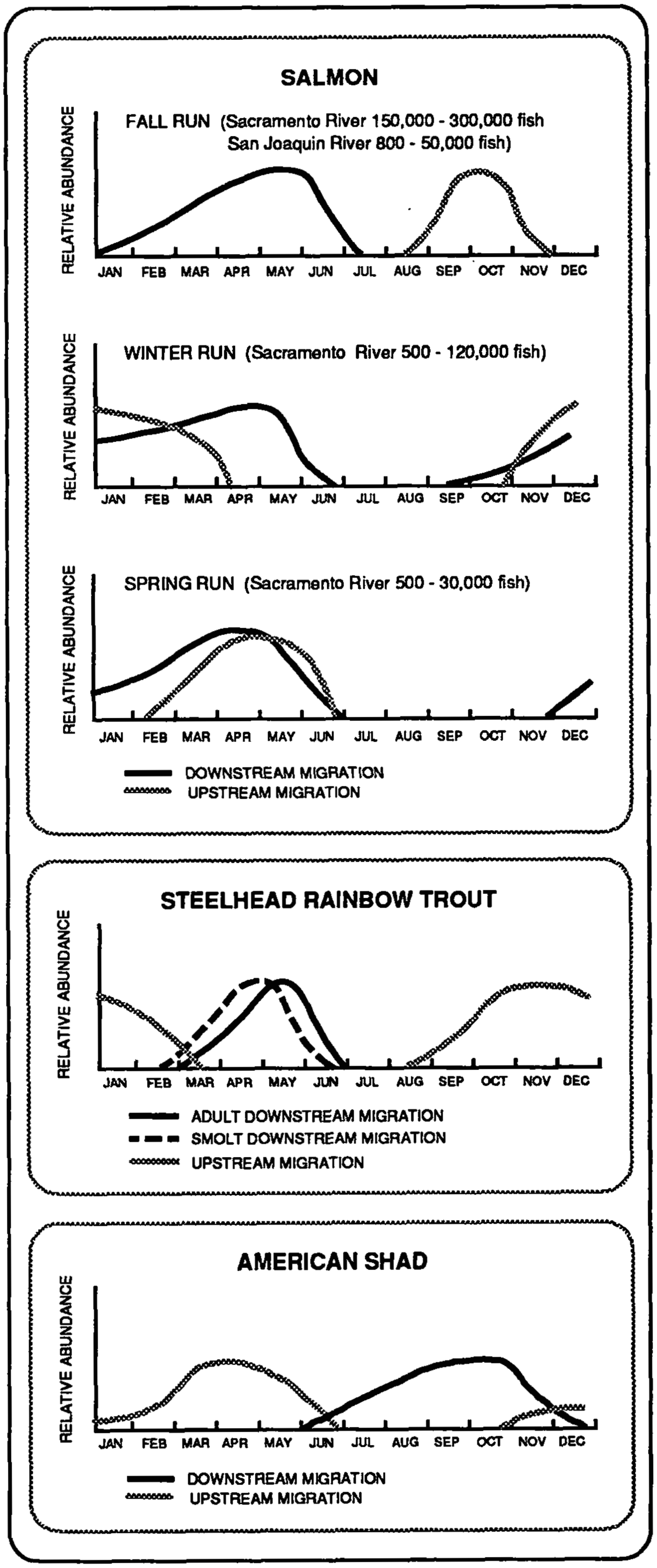


Figure 5-6. General Migration Patterns of Salmon Steelhead Rainbow Trout, and American Shad in the Sacramento-San Joaquin Estuary

winter—early spring river flows are high following emergence, there is a tendency for the young salmon (fry) to migrate or be transported downstream, where they rear in the lower river and Delta until they reach the smolt stage and are physiologically ready to enter salt water.

If low flow conditions prevail following emergence, the fry tend to rear in the upper river areas until they reach the smolt stage and then make a rapid downstream migration through the lower river and Delta in late spring. DFG studies indicate that the contribution of salmon fry tagged in the upper river to the ocean fishery is positively associated with late-winter early-spring river flow, suggesting that survival during the downstream migration is greater when they migrate earlier due to higher flows.

Considerable effort has gone into studying the factors affecting the survival of fall-run smolts during their downstream migration through the Delta. It now appears that increased water temperature, the proportion of Sacramento River flow diverted into the central Delta through the Delta Cross Channel and Georgiana Slough, and the total rate of exports by the CVP and SWP export facilities all appear to be closely correlated with Delta smolt survival. A recently developed smolt survival model using these three factors is employed later in this report to help quantify the impacts of the NDP.

There are generally three routes Sacramento drainage smolts can take through the Delta during their downstream migration. As they enter the Delta they can: 1) remain in the main stem Sacramento River the entire distance to Suisun Bay, 2) leave the main stem Sacramento River at Sutter and Steamboat sloughs and continue down those channels to Rio Vista, and 3) leave the main stem Sacramento River through the Delta Cross Channel and Georgiana Slough and migrate through the central Delta. Smolts taking the route through the central Delta generally survive at about one half the rate of fish taking the other two routes.

The mechanisms behind the relatively poor survival of fall-run smolts migrating through the central Delta are not known at this time. Possible mechanisms include 1) generally higher spring water temperatures in the central and southern Delta, 2) a longer, more complicated migration route, 3) higher predation rates, 4) complications in navigation caused by the hydrological effects of export pumping, and 5) greater exposure to direct mortality at the CVP and SWP export facilities due to predation, screening, and handling.

Sacramento River smolts diverted into the Delta through the Delta Cross Channel can continue through the Delta by going down either the South or North Fork of the Mokelumne River. It is not presently known what proportion of smolts migrate down each fork or what specific routes they take after entering the two forks. However, since the North Fork carries a greater net flow it is likely that more smolts migrate down the North Fork. Experimental releases of tagged or marked smolts into the two forks of the Mokelumne River have demonstrated some beneficial results, as measured by survival to Chipps Island, of taking one route over another with the present channel configuration and hydrological characteristics in this part of the Delta. Increased smolt survival in the North Fork was found in two of the three release experiments (USFWS 1989).

Winter-run Chinook Salmon. The timing of events in the life cycle of winter-run chinook salmon is quite different than that of the fall run salmon. Adult winter-run salmon pass through the Delta principally during January through March, several months later than the fall-run. Spawning occurs from mid-April to mid-August, peaking in late June or early July. Winter-run fry begin migrating from the spawning areas in early September and may enter the Delta soon afterwards. Whereas fall-run smolts typically pass through the Delta during April, May, and June, winter-run do so during December through April.

Winter-run salmon spawning historically occurred primarily in the upper Sacramento, Pit, and McCloud River drainage, where relatively cool water temperatures prevail in the summer incubation period. The construction of Shasta Dam in 1942 prevented access to the historical spawning grounds, but summertime releases of cool water from the hypolimnion of Shasta Lake created favorable incubation conditions in the main stem Sacramento River below the Dam and the winter-run population actually increased in size.

The subsequent decline of winter-run salmon has been attributed primarily to the operation of Red Bluff Diversion Dam, which prevented or delayed access to the favorable spawning ground below Shasta Dam. Another major problem for winter-run salmon in some years is the increasing occurrence of high water temperatures below Shasta Dam in summer and early fall. This condition occurs when the water levels are low in Shasta Lake and releases to the river come from warm surface waters. Other mortality factors include toxic discharge from Iron Mountain Mine, entrainment at poorly screened diversions, and stranding of juveniles during major flow fluctuations in the rearing area.

Relatively little information is available on how conditions in the Delta affect winter-run salmon. It is unlikely that water temperature is as important as it is for fall-run smolts, because winter-run smolts migrate through the Delta earlier in the year when it is very unlikely that Delta waters would be detrimentally warm. Due to periodic closure of the cross-channel gates from higher levels of runoff during late winter and early spring, a smaller proportion of winter-run smolts are diverted from the main stem Sacramento River into the central Delta through the Delta Cross Channel. Howeverc, like fall-run smolts the winter-run smolts diverted into the central Delta will have a longer migration route and greater exposure to the effects of the CVP and SWP export facilities. However, estimates of winter-run smolt survival in the central Delta are not available.

Current salvage estimates for winter-run salmon involve stock identification based on size as the determining characteristic, although size alone, due to its high variability, is usually considered insufficient. DFG has estimated that 27,405 and 24,326 winter-run smolts were salvaged in 1981 and 1988, respectively. However, the extent and significance of entrainment losses are not known at this time.

Steelhead. Hatcheries are presently responsible for most of the steelhead production in the Sacramento River drainage. More than one-million yearling steelhead are reared and released each year from the three Sacramento River drainage hatcheries. The limited natural production occurs primarily in the tributaries.

Generally, young steelhead emigrate from the Sacramento River drainage during spring and early summer like the fall-run chinook salmon. Currently, little is known about how steelhead smolts respond to conditions in the lower rivers and Estuary during their emigration. Likewise, adults are migrating upstream at a time similar to adult fall-run chinook salmon, but again we know relatively little about how Delta conditions affect this migration. Since the basic environmental needs of the two species are similar, it can probably be assumed that the factors found to influence the better-studied fall-run salmon have similar effects on steelhead, except that migrating steelhead are larger.

Mokelumne River Stocks. Historically, the Mokelumne River had major fall and spring runs of chinook salmon (Fry 1961), and a viable steelhead population. Construction of dams and diversion of water has greatly reduced the size of the fall run and eliminated the spring run salmon and steelhead populations. The size of the fall run has fluctuated greatly in recent years, from less than 1,000 in many years to over 15,000 in 1983, averaging about 3,000. Following construction of Camanche Dam, concrete raceways were installed, referred to as the Mokelumne River Fish Installation (MRFI), to rear steelhead eggs brought from Nimbus Fish Hatchery. This program was considered unsuccessful, producing adult returns of 200 fish or less, but the MRFI is still used to produce salmon for release in the Estuary and 30,000 steelhead annually to support a resident trout fishery in the river below Camanche Dam. Steelhead are also reared to mitigate for losses at the SWP intake facilities.

DFG believes there are two primary reasons for the low natural production of fall-run chinook salmon in the Mokelumne River in the recent past. These are: 1) poor conditions for spawning and rearing caused by inadequate instream flow releases and poor water quality below Camanche Dam, and 2) the inability of adult salmon to navigate back to the Mokelumne River because of the combination of low fall Mokelumne River flows and the high proportion of Sacramento River water in the Delta. Significant natural production of chinook salmon can still occur in wet years, when spring releases from Camanche Dam are relatively high (Reynolds et al., 1990).

The same factors thought to limit natural production may also limit the effectiveness of the MRFI in supporting a fall run of chinook salmon in the Mokelumne River. Since, spawning adult returns are usually too low to provide the MRFI with an adequate number of eggs, eggs are supplied to the Mokelumne River Hatchery from other hatcheries in the Central Valley. Because of the poor juvenile rearing and migration conditions in the lower Mokelumne River, the fish are reared until they are approximately 5 inches long (larger than a typical smolt) and then trucked to various points downstream of the Delta to improve their survival to adulthood. Releasing the hatchery-reared fish below the Delta reduces their chances of navigating back to the Mokelumne River, but increases their contribution to sport and commercial fisheries in the ocean and the sport fishery in the Sacramento River system.

Under present Mokelumne River fisheries management practices only the offspring of adults spawning in the stream migrate as juveniles downstream through the Delta, where they might be influenced by conditions in the Delta. The timing of juvenile emigration is not clearly understood, but the available evidence suggests that there is substantial movement of fry into the Delta in March followed by a migration of smolts in late May. There have been no specific studies of the factors influencing the survival of juvenile Mokelumne River salmon emigrating through the Delta, but it would seem likely that the association between survival and the combination of exports and temperature observed for diverted Sacramento River smolts would be applicable to Mokelumne River smolts.

San Joaquin River Drainage Stocks. The San Joaquin River drainage presently supports only fall-run chinook salmon, although historically there were major spring runs. There are presently no viable steelhead populations in the drainage. Large rainbow trout, which may be steelhead, are sometimes caught in the Stanislaus River. This report contains only an assessment of NDP effects on the remaining fall-run stocks of chinook salmon, because present salmon management in the San Joaquin drainage is focused on these stocks. Each of the three major tributaries to the San Joaquin River—the Stanislaus, Tuolumne, and Merced rivers—supports significant runs of fall-run salmon. The main stem San Joaquin River above the confluence with the Merced River no longer supports any significant salmon runs. The annual contribution made by San Joaquin tributaries to total Central Valley salmon production has been highly variable in recent decades, ranging from less than 1 percent to almost 20 percent.

The extirpation of the spring-run stocks and a decline in fall-run stocks has occurred in recent decades. The reasons behind these declines and the identification and implementation of maintenance and restoration measures are presently the subject of considerable research, management, and regulatory effort. Much of this effort is focused on improving conditions upstream of the Delta, including instream flows for rearing and juvenile migration, quality and access to spawning gravels, and upstream temperature conditions.

Conditions in the Delta can also influence San Joaquin drainage fall-run salmon. The fall upstream migration of adult salmon can be impeded by areas of low dissolved oxygen that can develop in the San Joaquin River near Stockton. Presently, the major cause of these low oxygen levels is apparently the combination of low river flows and organic sediments. Southern Delta pumping, including exports by the CVP and SWP, may aggravate this condition by reducing or reversing flows in this area. Mitigation for this condition has included installation of a temporary barrier in Old River during the late summer through early fall to create a downstream flow in the San Joaquin River past Stockton.

Salmon navigate back to their natal spawning grounds using the scent of the water, which they imprint on during rearing. Although not clearly documented, the migration of adult salmon through the Delta into the San Joaquin River drainage may be inhibited by the low proportion of San Joaquin River water flowing through the Delta. The proportion of San Joaquin River water in the Delta was low historically but has been made lower by water project operations.

However, while unsuitable conditions for returning adult spawners may have contributed to the decline in San Joaquin River drainage salmon stocks, most recent variation in stock size appears to be due to variation in conditions for juvenile rearing and emigration. It has been observed that the number of adults returning to spawn (escapement) from a particular year class is associated with the San Joaquin River flow (measured at Vernalis) in the spring of the year that cohort was rearing and emigrating. There are many possible mechanisms underlying this association, some of which could be acting in upstream areas and others in the Delta.

The Interagency Ecological Study Program (IESP) in cooperation with Region 4 of DFG has initiated studies designed to determine how conditions in the Delta influence the survival of emigrating San Joaquin River drainage smolts. Although these efforts have not progressed far enough to provide a complete understanding of Delta smolt survival, a few tentative conclusions have been drawn. A fundamental conclusion is that conditions in the Delta can be a major source of mortality for smolts emigrating from the San Joaquin River drainage. The average estimated survival to Chipps Island of smolts experimentally released in the head of Old River and in the San Joaquin River just below the head of Old River has averaged about 32 percent in recent experiments. In contrast, 80 to 90 percent of smolts released at Jersey Point survive to reach Chipps Island (USFWS 1989).

Another conclusion of recent studies is that the route taken through the Delta by emigrating smolts can strongly affect their rate of survival. Specifically, it appears that smolts emigrating down upper Old River survive at lower rates than smolts emigrating down the San Joaquin River past the head of Old River. It is likely that more of the smolts emigrating down Old River are entrained at the CVP and SWP export facilities and that lower survival rates of smolts emigrating down Old River is largely caused by entrainment–related losses, such as predation and loss through fish screens.

Another tentative conclusion is that the proportion of smolts entering the head of Old River is roughly equivalent to the proportion of San Joaquin River flow that is diverted into the head of Old River. It is often the case during the spring months that a large proportion (in some cases more than 100 percent) of net San Joaquin River flow goes down Old River, and that CVP and SWP export operations are known to contribute to the drawing of San Joaquin River water down the upper Old River.

It also has been estimated that roughly 10 to 20 percent of smolts experimentally released in the San Joaquin River below the head of Old River are entrained. This suggests the possibility that smolts can be drawn up the lower Old and Middle rivers by the reverse flows in these channels due to water project exports and in Delta pumping. The effect of tide stage, water project operations, and other factors on the routes taken by emigrating smolts is the subject of ongoing interagency studies. These conclusions are based on initial experiments carried out by the USFWS (1987 and 1989), and tests with a wider range of flow and habitat conditions are needed to confirm the data.

Impact of NDP

Tables 5–13 through 5–19 summarize monthly water levels, flows, diversion ratios and their relationships under the no–action and preferred alternatives which could affect salmon and steelhead populations. These tables are derived from monthly average flows from 1960–1978 hydrologic data modeled using the 57–year operations studies described in Appendix C. The monthly average flows simulated were in the Feather,Sacramento, Mokelumne, Middle, Old and San Joaquin rivers, the Delta cross–channel, and Georgiana Slough. Lake Oroville water elevations levels, monthly flows and ratios diverted, and monthly exports were calculated on the basis of the model results derived from hydrodynamic modeling described in Appendix C.

Tables 5–13 and 5–14 show the mean end–of–month Lake Oroville water elevations and mean monthly Feather River flows, respectively. Higher reservoir levels will increase the amount of cooler water available for release for salmonids. Changes in flow patterns and amounts can cause variations in spawning and rearing habitat, or change conditions for outmigration during the spring and summer.

The average monthly percentages of Sacramento river flow diverted into the central Delta through the Delta cross-channel and Georgiana Slough are shown in Tables 5-15, 5-16 and 5-18. Increased diversions of Sacramento River flow into the central Delta increases the incidence of salmonids straying from the preferred migration path down the Sacramento River, causing more salmonids to enter the central Delta. Tables 5-15 through 5-17 summarize flows, ratios and relationships which could affect Sacramento and Mokelumne river fall-run salmon and steelhead populations. Table 5-18 summarizes flows and diversion ratios associated with the months when winter-run salmon are migrating through the Delta.

USFWS has developed a Delta survival model for juvenile fall-run salmon from the Sacramento River drainage. This model relates survival of fall-run smolt emigrating from Sacramento to Chipp's Island to Sacramento River temperature, diversion of Sacramento River flow into the central Delta, and SWP/CVP export levels. This model was used to calculate seasonal mortalities for Sacramento River smolts for the no action and preferred alternatives (Table 5-16). Fall-run smolt survival appears to be very sensitive to Sacramento River water temperature. The NDP could affect the water temperature due to decreased river flows, but current D-1485 protective measures will maintain water quality and temperatures in the river.

Table 5-19 presents mean April-June net channel flows in the upper and lower San Joaquin rivers, the lower Middle River and lower Old River. Current problems due to reverse flows in the San Joaquin River would be reduced with project alternatives decreasing mortality during the fall-run smolt migration period.

No-Action Alternative. With existing conditions in the north Delta, flow patterns would remain similar to those occurring today. The flooding potential would remain high due to flow constraints and inadequate channel capacities in the Mokelumne River system. During low-flow conditions this limited capacity would force more water to flow down the Sacramento River and around Sherman Island, producing reverse flow conditions in the western Delta.

Undesirable reverse flow conditions for salmon and steelhead would continue and salmon populations would at best remain unchanged. With no modifications to the existing channels, more of the salmon diverted into the central Delta migrate down the longer route in the south fork of the Mokelumne River, which exposes them to reverse flows for a longer period.

Table 5-16 indicates that under the no-action alternative, mortality of juvenile salmon emigrating from Sacramento to Chipps Island could range from 58.2% (April of representative below normal year) to 85.2% (June of representative dry year). Sacramento River smolt mortality is 2.0 - 3.5% lower for the no-action alternative, compared to the preferred alternative, because Sacramento River diversions through the Delta cross-channel are less.

Preferred Alternative. Each of the individual Central Valley salmon and steelhead runs described in the following paragraphs are likely to be affected differently by the

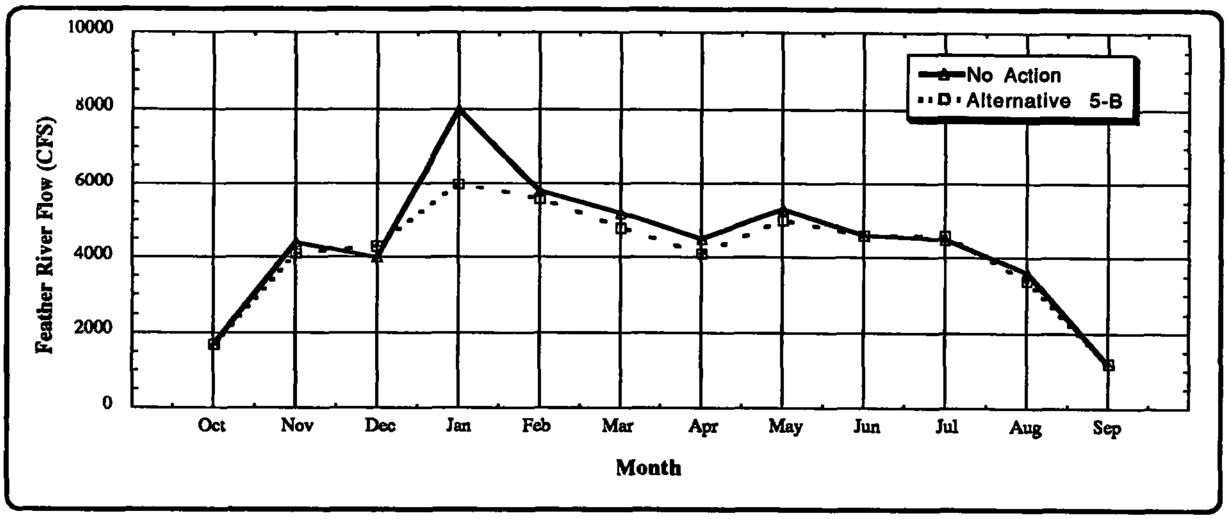


Figure 5-7. Average Monthly Flow (cfs) in the Feather River Below Thermalito Afterbay

NDP; thus, a separate discussion of impacts for each run is provided.

Sacramento River Fall-Run Chinook Salmon. Anticipated Oroville Reservoir levels are generally higher for the Preferred alternative than for the No-action alternative, particularly for the the drier year types (Table 5-13). This is not likely to positively affect the temperature of releases made to the Feather River, because the dam can already be operated to release water from multiple levels and the temperature of releases controlled. However, higher reservoir levels will increase the amount of cooler water available for release.

The Preferred alternative (5B) is used in Figure 5-7 to demonstrate how, on an average annual basis, Feather River flows would differ between the Preferred alternative, 5B, and the No-action alternative. The differences between the No-action alternative and the Preferred alternative are small, but January-through-June Preferred alternative flows are lower, indicating that, on average, salmon incubation and rearing habitat may be reduced.

Table 5-14 compares predicted Feather River flows between the Preferred alternative, 5B, and the No-action alternative for each year type. Substantial changes in flow occur in some months of all the year types. During the October-through-December fall-run spawning season, mean monthly flows decrease by 3 to 14 percent in the critical and dry years, which may reduce spawning habitat for those years. During the wetter years, monthly spawning season flows either increase or change very little. Flow effects also vary considerably among year types during the January-through-May rearing and emigration period. The Preferred alternative flows are generally higher than No-action flows during this time and should increase fish survival in critical years.

Table 5-13
Estimated Mean End-of-month Lake Oroville Water Level Elevations for the No-Action Alternative and Preferred (5B) Alternative, 1960-1978 (feet)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep
					Critical Year Mean							
No-Action	776	753	734	733	735	743	741	738	722	694	679	673
Preferred (5B)	782	765	752	749	752	759	753	749	732	706	692	685
Difference[1]	6	12	18	16	17	16	12	11	10	12	13	12
					Dry Year Mean							
No-Action	801	786	780	780	796	810	821	820	798	774	760	753
Preferred (5B)	811	'802	798	803	820	832	839	838	821	799	783	777
Difference	10	16	18	23	24	22	18	18	23	25	23	24
					Below-Normal Year Mean							
No-Action	805	791	785	789	818	841	860	864	848	823	807	802
Preferred (5B)	819	805	799	806	832	853	869	873	858	833	816	812
Difference	14	14	14	17	14	12	9	9	10	10	9	10
					Above-Normal Year Mean							
No-Action	785	778	777	794	815	827	866	875	864	838	817	813
Preferred (5B)	794	789	788	805	825	836	873	881	869	843	823	821
Difference	9	11	11	11	10	9	7	6	5	5	6	8
					Wet Year Mean							
No-Action	794	796	826	840	849	869	894	898	891	868	845	844
Preferred (5B)	802	806	829	841	849	869	894	898	891	868	849	850
Difference	8	10	3	1	0	0	0	0	0	0	4	6

[1]Differences in Lake Oroville water elevations indicate the increase expected for the Preferred alternative.

Table 5-14
Estimated Mean Monthly Feather River Flows for the No-Action and Preferred (5B) Alternatives, 1960-1978 (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep
Critical Year Mean												
No-Action	3,346	6,116	5,699	5,046	5,238	3,244	3,511	3,230	3,799	3,201	2,074	2,395
Preferred (5B)	3,251	5,618	4,923	5,331	4,753	3,399	4,088	3,309	4,078	2,922	2,142	2,445
Difference[1]	-95	-498	-776	+285	-485	+155	+577	+79	+279	-279	+68	+50
% Difference[1]	-3	-8	-14	+6	-9	+5	+16	+2	+7	-9	+3	+2
Dry Year Mean												
No-Action	3,467	5,935	4,795	6,090	8,300	6,862	5,977	5,514	5,864	4,042	2,586	2,910
Preferred (5B)	3,405	5,128	4,345	5,478	7,656	6,648	6,569	5,518	5,869	3,964	2,809	2,929
Difference	-62	-807	-450	-612	-644	-214	+592	+4	+5	-78	+223	+19
% Difference	-2	-14	-9	-10	-8	-3	+10	0	0	-2	+9	+1
Below-Normal Year Mean												
No-Action	3,405	5,668	5,857	6,531	9,686	9,257	6,184	6,117	6,762	6,540	4,541	3,414
Preferred (5B)	3,576	6,069	5,748	5,844	9,939	9,195	6,296	6,119	6,765	6,900	4,853	3,286
Difference	+171	+401	-109	-507	+253	-62	+112	+2	+3	+360	+312	-128
% Difference	+5	+7	-2	-8	+3	-1	+2	0	0	+6	+7	-4
Above-Normal Year Mean												
No-Action	3,234	4,975	5,844	7,521	10,287	14,299	9,758	10,378	7,928	7,561	6,083	3,606
Preferred (5B)	3,234	4,892	5,982	7,388	10,668	14,380	9,796	10,379	7,929	7,782	6,011	3,312
Difference	0	-83	+138	-133	+381	+81	+38	+1	+1	+221	-72	-294
% Difference	0	-2	+2	-2	+4	+1	0	0	0	+3	-1	-8
Wet Year Mean												
No-Action	4,005	6,001	11,168	24,752	24,563	17,391	16,036	16,714	11,358	8,977	7,806	3,571
Preferred (5B)	4,008	5,831	12,255	25,121	24,700	17,401	16,042	16,704	11,357	9,003	6,791	3,260
Difference	+3	-170	+1,087	+369	+137	+10	+6	-10	-1	+26	-1,015	-311
% Difference	0	-3	+10	+1	+1	0	0	0	0	0	-13	-9

[1]Negative differences indicate reductions in flow for the Preferred alternative.

In the dry years, preferred alternative flows are lower from January through March, but are higher in April. Mean monthly preferred and no-action rearing and migration-period flows are generally very similar during the three wetter year types and during May and June for dry years. Thus, for all periods except January through March of dry years, flows during the rearing and migration period either do not affect or are beneficial to salmon.

Sacramento River water entering the central Delta through the Delta Cross-Channel and Georgiana Slough can cause adult salmon to migrate into the lower San Joaquin and Mokelumne rivers, delaying their spawning migration. The Preferred alternative increases the proportion of Sacramento River flow diverted into the central Delta during the July-through-November migration period (Table 5-15). The increases in percentage diverted during July through November range from approximately 12 to 16 percent. The increases in percentage diverted are likely to increase the incidence of straying.

Chinook salmon fry move into the Delta during February and March, and the Program alternatives increase the percentage of Sacramento River flow diverted into the central Delta during these months in critical and dry years (Table 5-15). Too little is known about the effects of Delta conditions on fry survival to enable a detailed assessment of the impact of these increases. Smolt survival is negatively affected by diversion into the Delta and fry may respond similarly.

Table 5–16 shows the anticipated differences in mortality of fall–run smolts migrating through the Delta between the No–action Alternative and the Preferred Alternative 5B. The mortality values shown in Table 5–16 were calculated using the IESP model developed by USFWS (Kjelson et al 1989) which predicts the mortality of fall–run smolts migrating through the Delta based on three factors: 1) water temperature in the Sacramento River below the city of Sacramento, 2) the proportion of Sacramento River flow diverted into the central Delta, and 3) the total rate of water export by the CVP and SWP export facilities. Figure 5–8 illustrates how these three factors interact in the model to affect smolt mortality.

As indicated in Table 5–16, export levels are very similar for the No–action and Preferred alternatives during April through June. It is predicted, however, that the fraction of Sacramento River flow diverted into the central Delta through the Delta Cross–Channel and Georgiana Slough will be greater with the Preferred alternative. The increases in fraction diverted are greatest in the dryer years and months, averaging about 30 percent. The increases are smaller in April of the above–normal and wet years because the Delta Cross–Channel is often closed at those times. The increases in fraction diverted cause increases in predicted mortalities in all year types. The largest average increase occurs in the below–normal years, when the mortality for the season is about 3.5 percent greater than that for the No–action alternative.

The model used to calculate the mortality values in Table 5–16 (Kjelson et al. 1989) is based on measurements of smolt survival under varying flow and SWP/CVP export conditions with the present configuration (i.e. location and capacity) of Delta channels. The proposed Preferred alternative modifies the channels, changing flow patterns in parts of the central and northern Delta. The routes taken by smolts migrating through the Delta are influenced by the flow patterns they encounter; thus, the Preferred alternative could affect the migration path

Table 5–15
Estimated Mean Monthly Percentage of Sacramento River Flow Diverted into the Central Delta Through the Delta Cross–Channel and Georgiana Slough for the No–Action and Preferred (5B) Alternatives[1], 1960–1978 (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep
Critical Year Mean												
No–Action	41.7	38.1	40.0	46.0	44.9	45.4	47.0	46.4	46.0	45.9	48.9	50.0
Preferred (5B)	55.3	52.5	55.5	58.9	59.5	61.0	61.5	60.9	60.3	59.9	63.9	65.5
Difference	–13.6	–14.4	–15.5	–12.9	–14.6	–15.6	–14.5	–14.5	–14.3	–14.0	–15.0	–15.5
Dry Year Mean												
No–Action	44.7	37.1	40.3	29.6	26.9	39.6	39.6	40.8	41.2	38.4	46.0	46.0
Preferred (5B)	59.6	51.3	55.3	38.1	35.2	53.9	52.9	54.6	55.1	52.0	60.1	61.9
Difference	–14.9	–14.2	–15.0	–8.5	–8.3	–14.3	–13.3	–13.8	–13.9	–13.6	–14.1	–15.9
Below–Normal Year Mean												
No–Action	40.9	37.8	38.7	25.4	14.1	14.5	38.8	40.4	39.8	37.5	42.3	45.3
Preferred (5B)	54.7	51.5	52.7	32.1	14.3	14.7	52.4	54.1	53.4	50.3	56.8	61.5
Difference	–13.8	–13.7	–14.0	–6.7	–0.2	–0.2	–13.6	–13.7	–13.6	–12.8	–14.5	–16.2
Above–Normal Year Mean												
No–Action	36.8	36.2	36.1	15.7	12.7	12.4	14.4	29.9	32.5	36.3	36.8	39.0
Preferred (5B)	50.3	47.7	49.1	16.0	12.8	12.5	14.6	39.2	44.1	49.1	51.2	53.3
Difference	–13.5	–11.5	–13.0	–0.3	–0.1	–0.1	–0.2	–9.3	–11.6	–12.8	–14.4	–14.3
Wet Year Mean												
No–Action	42.7	39.0	31.8	15.8	13.0	15.7	20.6	31.9	33.8	36.2	38.0	42.1
Preferred (5B)	57.1	52.9	42.3	17.4	13.1	17.3	25.1	42.5	45.4	48.9	52.7	57.7
Difference	–14.4	–13.9	–10.5	–1.6	–0.1	–1.6	–4.5	–10.6	–11.6	–12.7	–14.7	–15.6

[1]Percentage diverted = Cross–Channel flow + Georgiana Slough flow/Sacramento River flow (as measured at Freeport).

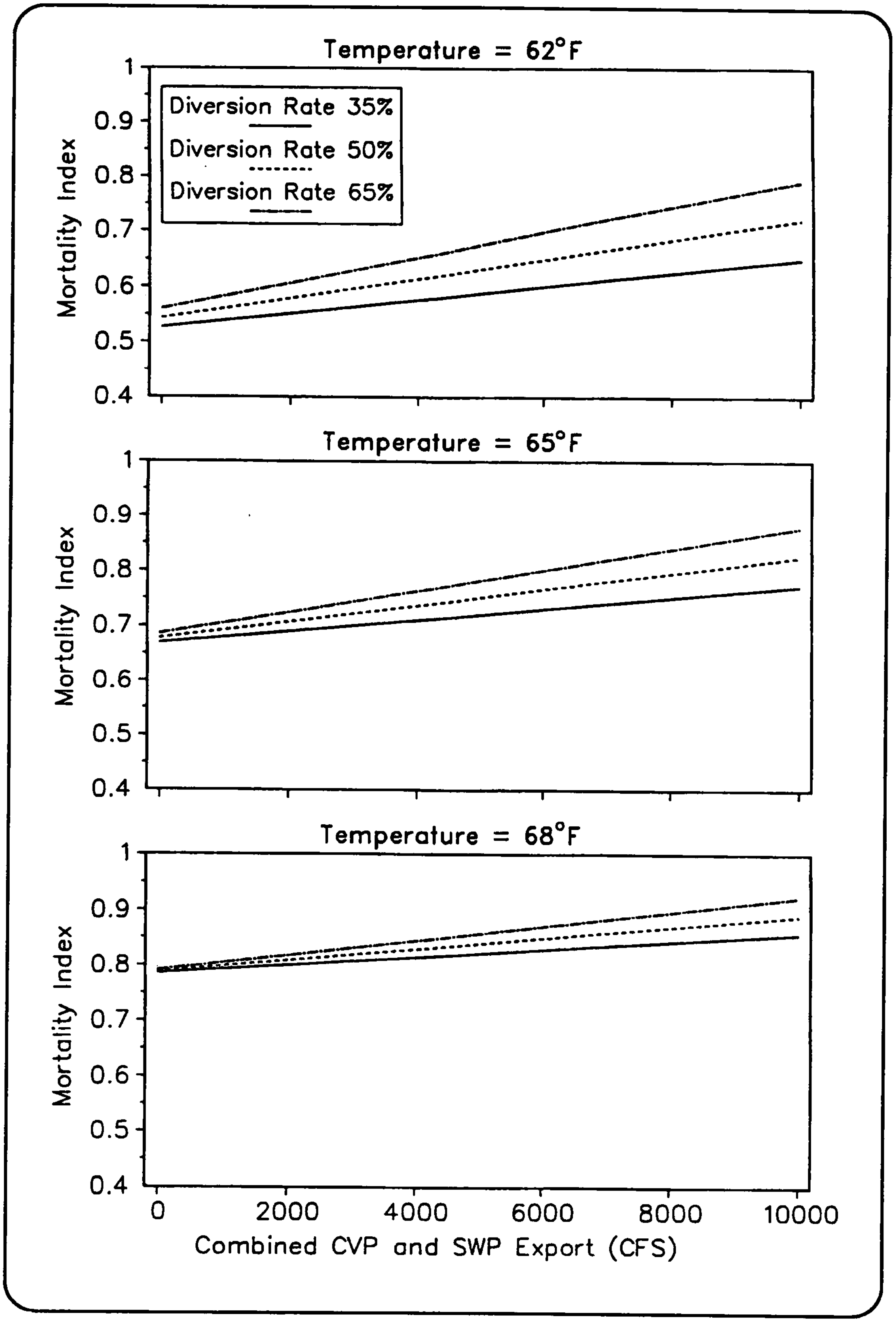


Figure 5-8. Predicted Survival of Smolts Migrating from Sacramento to Chipps Island at Various Level of Exports, Temperature, and Delta Cross-Channel Diversions

Table 5-16

Predicted Mortality of Fall-run Sacramento River Drainage Salmon Smolts Emigrating through the Sacramento-San Joaquin Delta During April through June for the No-Action and Preferred (5B) Alternative Conditions. (Mortality estimates are based on the mortality equation developed by Kjelson et al.[1] [1989])

	Total Exports[2]			Fraction Diverted[3]			Mortality[4]			
	April	May	June	April	May	June	April	May	June	Season
				Critical Year Mean (2)[5]						
No-Action	5,472	4,210	3,271	0.586	0.581	0.579	0.666	0.754	0.834	0.765
Preferred (5B)	5,630	4,208	3,270	0.734	0.728	0.727	0.716	0.781	0.848	0.791
Difference	−158	2	1	−0.148	−0.147	−0.148	−0.050	−0.027	−0.014	−0.026
				Dry Year Mean (2)						
No-Action	8,190	4,992	5,008	0.515	0.525	0.532	0.696	0.757	0.852	0.776
Preferred (5B)	8,785	4,992	5,008	0.664	0.674	0.682	0.770	0.787	0.872	0.810
Difference	−595	0	0	0.149	0.149	0.150	−0.074	−0.030	−0.020	−0.034
				Below-Normal Year Mean (5)						
No-Action	9,079	5,126	5.008	0.506	0.521	0.519	0.708	0.758	0.850	0.778
Preferred (5B)	9,209	5,123	5,008	0.658	0.670	0.669	0.778	0.789	0.870	0.812
Difference	−130	3	0	−0.152	−0.149	−0.150	−0.070	−0.031	−0.020	−0.034
				Above-Normal Year Mean (1)						
No-Action	9,868	5,984	6,016	0.203	0.409	0.437	0.582	0.745	0.849	0.752
Preferred (5B)	9,444	5,984	6,016	0.205	0.523	0.580	0.580	0.772	0.872	0.773
Difference	424	0	0	−0.002	−0.114	−0.143	−0.002	−0.027	−0.023	−0.021
				Wet Year Mean (9)						
No-Action	8,497	5,790	5,133	0.285	0.429	0.453	0.607	0.747	0.842	0.755
Preferred (5B)	8,486	5,789	5,133	0.336	0.557	0.592	0.628	0.776	0.861	0.779
Difference	11	1	0	−0.051	−0.128	−0.139	−0.021	−0.029	−0.019	−0.024

[1]Kjelson et al. (1989) Mortality equation "6" (using predicted total exports, fraction of Sacramento River flow diverted into the central Delta, and temperature at Freeport).
[2]Monthly mean total (CVP + SWP) export rate (cfs) for each year type during 1960 through 1978.
[3]Fraction diverted = (Georgiana Slough flow + Cross-Channel flow) / Sacramento River flow above Delta Cross-Channel.
[4]For all alternatives and year types the following temperature conditions were assumed. April, 62°; May, 65°; June, 68°. Likewise, the percentage of smolts migrating in April, May, and June were assumed to be 15%, 55%, and 30%, respectively.
[5]Sample size (i.e., the number of years in the 1960-1978 period of each year type).

through the central Delta of smolts diverted through the Delta Cross-Channel.

On three occasions, experimental releases of smolts have been made simultaneously in the North and South forks of the Mokelumne River below the Delta Cross-Channel. However, these experiments have not clearly indicated which route is most favorable for diverted smolts (USFWS 1987). Migrating down the North Fork to the San Joaquin River is the shortest, most direct route and minimizes exposure to export-related reverse flows in the lower Old and Middle rivers and in two of the three release experiments mentioned above, the survival of smolts released in the North Fork was higher. With the present Delta channel configuration, water diverted through the Delta Cross-Channel tends to flow down the North Fork to the San Joaquin River. Implementation of the Preferred alternative 5B would increase the propor-

Table 5-17
Estimated Mean Monthly Flow in the Sacramento River downstream from Georgiana Slough for the No-Action and Preferred (5B) Alternatives, 1960-1978 (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep
Critical Year Mean												
No-Action	5,429	6,672	5,642	3,587	4,054	3,917	3,021	3,065	3,176	3,131	2,501	2,407
Preferred (5B)	3,952	4,722	3,645	2,939	2,751	2,376.	2,065	2,061	2,124	2,196	1,613	1,494
Difference	-1,477	-1,950	-1,997	-648	-1,303	-1,541	-956	-1,004	-1,052	-935	-888	-913
% Difference	-27	-29	-35	-18	-32	-39	-32	-32	-33	-30	-36	-38
Dry Year Mean												
No-Action	3,901	7,398	5,714	8,059	9,927	6,094	5,585	4,773	4,830	6,462	3,345	3,427
Preferred (5B)	2,620	5,098	3,783	7,268	8,688	4,177	4,150	3,399	3,388	4,573	2,394	2,196
Difference	-1,281	-2,300	-1,931	-791	-1,239	-1,917	-1,435	-1,374	-1,442	-1,889	-951	-1,231
% Difference	-33	-31	-34	-10	-12	-31	-26	-29	-30	-29	-28	-36
Below-Normal Year Mean												
No-Action	4,841	7,023	6,150	9,891	16,760	13,118	5,743	4,971	5,440	7,016	4,739	3,657
Preferred (5B)	3,607	4,991	4,341	9,073	16,729	13,120	4,154	3,559	3,869	5,144	3,273	2,326
Difference	-1,234	-2,032	-1,809	-818	-31	+2	-1,589	-1,412	-1,571	-1,872	-1,466	-1,331
% Difference	-25	-29	-29	-8	0	0	-28	-28	-29	-27	-31	-36
Above-Normal Year Mean												
No-Action	6,270	7,327	7,219	9,543	27,846	36,653	12,454	14,682	9,218	7,635	7,623	5,571
Preferred (5B)	4,558	5,941	5,273	9,515	27,807	35,609	12,423	12,124	7,019	5,499	4,966	3,923
Difference	-1,712	-1,386	-1,946	-28	-39	-44	-31	-2,558	-2,199	-2,136	-2,657	-1,648
% Difference	-27	-19	-27	0	0	0	0	-17	-24	-28	-35	-30
Wet Year Mean												
No-Action	4,654	7,270	13,922	29,309	25,948	22,679	18,708	11,930	9,098	7,518	6,533	4,652
Preferred (5B)	3,264	5,299	11,786	29,356	25,912	22,450	18,080	9,722	7,032	5,495	4,465	3,085
Difference	-1,390	-1,971	-2,136	+47	-36	-229	-628	-2,208	-2,066	-2,023	-2,370	-1,567
% Difference	-30	-27	-15	0	0	-1	-3	-19	-23	-27	-35	-34

tion of flow down the North Fork, thus minimizing exposure to reverse flows in the lower Old and Middle rivers.

Except when the Delta Cross-Channel is closed, the Preferred alternative increases the percentage of Sacramento River flow diverted through the Delta Cross-Channel (Table 5-15) and, in turn, reduces the flow in the Sacramento River below the Cross-Channel. Table 5-17 shows the differences between the No-action Alternative and the Preferred alternative 5B. During April through June, the reductions in mean monthly flow range from 0 to 33 percent. During critical, dry, and below normal years, the reductions range from 26 to 33 percent. Our present limited understanding of the factors affecting smolt survival suggests that river flow below the Cross-Channel, in and of it self, is not a significant factor directly influencing smolt survival (Kjelson et al 1989). However, reduced flows could reduce survival by causing increases in spring water temperature in this reach.

Sacramento River Winter-Run Chinook Salmon. Adult winter-run salmon migrate through the Delta during January through April. Winter-run adults are probably subject to straying caused by diversion of Sacramento River water into the central Delta through the Delta Cross-Channel and Georgiana Slough, but no specific studies have been done on adult winter-run migrations through the Delta. The Preferred alternative increases the proportion of Sacramento River flow diverted into the Delta during all months of the January-through-April migration period in critical and dry years, and in both January and April of below-normal years (Table 5-18). The percentage diverted changes very little during other months and year types because the Delta Cross-Channel is closed at these times.

Winter-run smolts are migrating downstream through the Delta during January through April. If, as is the case with fall-run smolts, diversion into the central Delta negatively affects winter-run smolt survival, the increased diversion rate in the drier years could reduce winter-run smolt survival.

Mokelumne River Fall-Run Chinook Salmon. As described above in the discussion of No-action alternative effects on Mokelumne River smolts, total (CVP + SWP) exports and water temperature can be used to predict smolt mortality. Smolt mortality in the Delta is sensitive to temperature, but the Preferred alternative is not expected to affect temperature conditions in the Delta. The Program alternatives are also not expected to affect export rates substantially when compared to the No-action alternative (Table 5-16). The estimated differences in mean monthly mortality rates between the Preferred and No-action alternatives are substantially less than 1 percent for all months and year types.

Like Sacramento River smolts diverted into the Delta Cross-Channel, Mokelumne River smolts migrating through the Delta could be detrimentally affected by the changes in flow patterns shown in Figure 3-2.

San Joaquin River Fall-Run Chinook Salmon. The Preferred alternative will improve habitat conditions for San Joaquin River fall-run chinook salmon migrating through the Delta. As shown in Table 5-19, the Preferred alternative will increase net flow in the San Joaquin River below its confluence with the lower Middle River, which should benefit migrating smolts. Export rates do not substantially differ between the No-action alternative and the Preferred alternative; therefore, the Preferred alter-

Table 5-18
Estimated Mean Monthly (CVP & SWP) Exports and Percentage of Sacramento River Flow Diverted Through the Delta Cross-Channel and Georgiana Slough for the No-Action and Preferred (5B) Alternatives During Months When Winter-run Salmon Adults and Smolts are Migrating Through the Delta (1960-1978)

	SWP & CVP Exports (cfs)					Sacramento River Diversion (%)[1]				
	Jan	Feb	Mar	Apr	Mean	Jan	Feb	Mar	Apr	Mean
Critical Year Mean										
No-Action	7,557	7,018	7,064	5,472	6,778	46.0	44.9	45.4	47.0	45.8
Preferred (5B)	9,500	7,888	7,066	5,630	7,521	58.9	59.5	61.0	61.5	60.2
Difference	-1,943	-870	-2	-158	-743	-12.9	-14.6	-15.6	-14.5	-14.4
Dry Year Mean										
No-Action	10,531	11,539	11,315	8,190	10,394	29.6	26.9	39.6	39.6	33.9
Preferred (5B)	10,757	11,560	11,379	8,785	10,620	38.1	35.2	53.9	52.9	45.0
Difference	-226	-21	-64	-595	-226	-8.5	-8.3	-14.3	-13.3	-11.1
Below-Normal Year Mean										
No-Action	10,726	11,173	10,338	9,079	10,329	25.4	14.1	14.5	38.8	23.2
Preferred (5B)	10,860	11,173	10,284	9,209	10,382	32.1	14.3	14.7	52.4	28.4
Difference	-134	0	54	-130	-53	-6.7	-0.2	-0.2	-13.6	-5.4
Above-Normal Year Mean										
No-Action	7,473	11,621	11,464	9,868	10,107	15.7	12.7	12.4	14.4	13.8
Preferred (5B)	7,473	11,621	11,464	9,444	10,001	16.0	12.8	12.5	14.6	14.0
Difference	0	0	0	424	106	-0.3	-0.1	-0.1	-0.2	-0.2
Wet Year Mean										
No-Action	11,516	10,655	8,942	8,497	9,903	15.8	13.0	15.7	20.6	16.3
Preferred (5B)	10,967	10,669	8,842	8,486	9,741	17.4	13.1	17.3	25.1	18.2
Difference	549	-14	100	11	162	-1.6	-0.1	-1.6	-4.5	-1.9

[1]Percentage diverted = Cross-Channel flow + Georgiana Slough flow/Sacramento River flow (as measured at Freeport).

Table 5-19

Estimated Mean Monthly Net Channel Flows in Southern Delta Channels That May Influence San Joaquin River Drainage Fall-run Smolt Survival for the No-Action and Preferred (5B) Alternatives, 1960-1978 (cfs)

	Upper San Joaquin River[1]			Lower Middle River[2]			Lower Old River[3]			Lower San Joaquin R.[4]		
	April	May	June	April	May	June	April	May	June	April	May	June
Critical Year Mean												
No-Action	408	220	12	-2,216	-1,893	-1,889	-2,088	-1,903	-1,802	239	400	46
Preferred (5B)	401	223	14	-2,404	-2,006	-1998	-2,503	-2,289	-2,205	846	1,059	717
Difference	-7	+3	+2	-188	-113	-118	-415	-386	-403	+607	+659	+671
Dry Year Mean												
No-Action	230	149	-49	-3,433	-2,376	-2,643	-2,935	-2,420	-2,382	286	1,075	210
Preferred (5B)	211	155	-46	-3,857	-2,522	-2,800	-3,636	-2,935	-2,921	1,120	1,968	1,126
Difference	-19	+6	+3	-424	-146	-157	-701	-515	-539	+834	+893	+916
Below-Normal Year Mean												
No-Action	404	260	-40	-3,733	-2,350	-2,673	-3,118	-2,464	-2,482	136	1,313	542
Preferred (5B)	399	266	-37	-3,969	-2,495	-2,839	-3,721	-2,984	-3,061	1,118	2,225	1,531
Difference	-5	+6	+3	-236	-145	-166	-603	-520	-579	+982	+912	+898
Above-Normal Year Mean												
No-Action	673	156	27	-3,893	-3,240	-3,318	-2,753	-4,408	-3,410	565	6,941	2,401
Preferred (5B)	683	162	31	-3,769	-3,492	-3,531	-2,714	-5,273	-4,129	891	8,534	3,694
Difference	+10	+6	+4	124	-252	-213	39	-865	-719	+326	+593	+1,293
Wet Year Mean												
No-Action	1,781	1,682	1,053	-3,138	-2,301	-2,361	-4,024	-4,020	-3,263	8,981	7,791	4,493
Preferred (5B)	1,768	1,683	1,051	-3,212	-2,508	-2,554	-4,250	-4,778	-3,969	9,356	9,170	5,740
Difference	-13	+1	-2	-74	-207	-193	-226	-758	-706	+375	+1,379	+1,247

[1]RMA Channel Segment 24.
[2]RMA Channel Segments 160 + 161.
[3]RMA Channel Segment 124.
[4]RMA Channel Segment 51.

native should reduce problems associated with diversion of San Joaquin River water into upper Old River. The Preferred alternative does tend to intensify reverse flows in the lower Old and Middle rivers (Table 5-19), which is likely to increase entrainment of fall-run smolts and steelhead migrating through the Delta.

Steelhead. The biology of central valley steelhead is poorly understood in comparison to chinook salmon; thus, the assessment of Program effects on steelhead is necessarily less detailed. Steelhead will likely be detrimentally affected by the anticipated increases in the proportion of Sacramento River flow diverted through the Delta Cross-Channel. As with salmon, the greater levels of diversion may increase the incidence of straying of adults on their upstream spawning migration and reduce the survival of downstream migrant juveniles.

Other Alternatives. The other NDP alternatives would also reduce the magnitude and frequency of reverse flow in the western Delta, as shown in Table 5-7. More consistent downstream flow would reduce the number of salmon being pulled back upstream into the central and south Delta, where fish are more susceptible to entrainment. Alternatives 3B, 4B, 5B, and 6B, which include proposals for dredging and/or enlarging the North and South Fork Mokelumne rivers (3B, 4B, 5B), creation of an island floodway (6B), and enlargement of the Delta cross-channel gate structure (3B, 4B, 5B, 6B), provide the most benefits for reduction of reverse flow, particularly for the months of May–July (Table 5- 20).

Water quality for upstream spawning, egg incubation, rearing and outmigration above the Delta, in the Feather River, is affected similarly by the preferred and other alternatives. Some reduction in Feather River flow (3–14%) from October–December for critical and dry years may reduce spawning habitat for those years. Operational flexibility at Lake Oroville could improve fall spawning water temperature in the Feather River through cold water releases from the reservoir. The months from January through June are important to fall-run salmon for egg incubation, rearing and outmigration. For the NDP alternatives Feather River flows either increase (2–16%) or change very little for most years, which could benefit young salmon in this reach. However, from January through March of dry years flows are lower (3–10%) for project alternatives, possibly reducing habitat for that period.

All project alternatives increase the proportion of Sacramento River flow diverted into the central Delta, which can cause adult salmon to migrate into the lower San Joaquin and Mokelumne rivers, delaying their spawning migration. Increased Sacramento River diversions also affect salmon fry and smolts by altering migration paths and increasing the possibility of being drawn toward the CVP and SWP facilities.

The increase in mortality for Sacramento River fall–run smolts due to central Delta diversions ranged from 2–3.5%. The greater the proportion of Sacramento River water diverted (33% for the preferred alternative and alternatives 3B, 4B, and 6B), the higher the predicted mortality (Table 5–20). The estimated differences in mortality for Mokelumne River smolts are substantially less than one percent for all months and year types. Increased exports in June of critical years can contribute to these losses.

Although experimental releases of smolts in the North and South forks of the Mokelumne River below the Delta cross–channel were inconclusive (USFWS 1987, 1989), two of the three releases indicated increased survival for smolts released in the North Fork Mokelumne River. Those alternatives (the preferred alternative and alternative 5A) which include enlargement of the North Fork of the Mokelumne River to increase its capacity and create habitat through levee setbacks would have the greatest potential to divert salmon through the shortest, most direct route, thus minimizing exposure to export related reverse flows in the lower Old and Middle rivers.

Table 5–20
Impacts of Project Alternatives on Salmon and Steelhead
(Compared to Impacts of the No–action Alternative)

Alternatives	Delta Cross–Channel Diversion Losses	Reverse Flow	Water Quality Conditions in Feather River: Spawning Period (October–December)	Water Quality Conditions in Feather River: Egg Incubation, Rearing, & Outmigration (January–June)	Delta Outflow	SWP Exports	Delta Cross Channel Flow
2A, 3A, 4A, 5A	2% increase in mortality April–June.	Less frequent 20% Aug–Nov 30% April–July.	3–14% decrease in flows for critical and dry years, with possible reduction in spawning habitat. Flexibility to improve spawning water temperature with cold water releases from Lake Oroville.	Increased or similar flows for most years, beneficial to salmon; lower flows in Jan–Mar of dry years.	< 1% reduction April–July; 9% reduction in July of dry years.	1% increase May–July; 16% increase in June of critical years.	14% increase in proportion of Sacramento River flow diverted.
3B, 4B 5B, 6B	2–3.5% increase in mortality April–June.	Less frequent 40% Aug–Nov 85% Apr–July.	3–14% decrease in flows for critical and dry years, with possible reduction in spawning habitat. Flexibility to improve spawning water temperature with cold water releases from Lake Oroville.	Increased or similar flows for most years, beneficial to salmon; lower flows in Jan–March of dry years.	< 1% reduction April–July; 8% reduction in July of dry years.	2% increase May–July; 24% increase in June of critical years.	33% increase in proportion of Sacramento River flow diverted.
2B, 6A	3% increase in mortality April–June.	Less frequent 40% Aug–Nov 55% Apr–July.	3–14% decrease in flows for critical and dry years, with possible reduction in spawning habitat. Flexibility to improve spawning water temperature with cold water releases from Lake Oroville.	Increased or similar flows for most years, beneficial to salmon; lower flows in Jan–March of dry year.	< 1% reduction April–July; 8% reduction in July of dry years.	2% increase May–July; 24% increase in June of critical years.	30% increase in proportion of Sacramento River flow diverted.

Impacts of project alternatives on winter-run salmon and steelhead are not well known, although inferences based on data for fall-run salmon indicate that the increased diversion of Sacramento River flow into the central Delta could cause straying of adults from January–April of critical and dry years. An increase in mortality of smolts migrating down through the Delta system could also occur.

General Impacts on Striped Bass

The striped bass, *Morone saxatilis*, was introduced to the Bay/Delta in the late 1800s, when a few hundred juvenile fish collected from the Navesink and Shrewsbury rivers in New Jersey were planted. By the 1890s, the introduced fish had done so well that a commercial fishery had been established—hundreds were caught within the first 10 years. More than 1 million pounds were landed in California 20 years after the transplant, and from 1916 to 1935, the annual commercial catch ranged from 500,000 to 1 million pounds. Commercial fishing continued until 1935, when it was stopped to provide a better striped bass sports fishery. There has been a recent general decline in angler success, the direct result of a substantial decline in the adult striped bass population during the 1970s.

The NDP has the potential to impact the striped bass population in the Bay/Delta system. This section provides a general description of striped bass life history, current status of the population, a description of the factors thought to be controlling striped bass abundance, and an analysis of the impacts of the NDP.

Much of the detailed information regarding striped bass has been collected as part of a 1960s DFG/DWR cooperative study and an interagency (DWR, DFG, SWRCB, USGS, Reclamation, USFWS) study (1971 to date) of the Bay/Delta. Striped bass are collected and abundance indices are developed for various life stages from eggs through adults. Information is also collected on food supply, entrainment, and such environmental variables as the water's oxygen content, clarity, and salinity. Recent work by Stevens et al. (1990) provides additional analysis of the available data on the striped bass decline.

Life History. Unlike many East Coast populations, especially those from the Chesapeake Bay, California striped bass apparently spend most of their life cycle in the Bay/Delta and in the coastal ocean within a few miles of the Golden Gate. Striped bass have been caught as far south as Redondo Beach (Los Angeles County) and as far north as the State of Washington, indicating that some limited ocean migration has occurred. A small self-sustaining population was established in the Coos River in southern Oregon; however, their numbers have decreased dramatically in recent years.

Potential Factors Affecting Striped Bass Abundance

Food Supply
- Lower algal levels
- Change in algal bloom species
- Introduction of non-native invertebrates
- Lower levels of important native invertebrates

Egg Supply
- Lower numbers of fish
- Lower numbers of older fertile females

Adult Mortality
- Natural (including old age, disease, poaching, and toxics)
- Fishing

Toxics (from urban, industrial, mining, agricultural, and other sources)
- Treated waste
- Untreated waste
- Point runoff
- Non-point runoff

Entrainment
- State Water Project
- Central Valley Project
- Delta agriculture diversions
- Pacific Gas and Electric Company
- Delta Cross Channel

Outflow and Diversion Rates

Some adult striped bass move from San Francisco Bay in the fall, while others remain in the Bay and migrate to the Delta later. In the spring, adults undergo a spawning migration to the lower San Joaquin River and the Sacramento River between Isleton and Butte City. DFG has estimated that about 60 percent of the bass spawn in the Sacramento River and 40 percent spawn in the lower San Joaquin River.

For purposes of this analysis, adult bass are defined as those exceeding the minimum legal catchable size of 18 inches. About half of the bass reach this size at 3 years of age. Males can begin spawning at two years of age, but females are generally five years or older. The number of eggs per female (fecundity) varies directly with size and age and can range from a few hundred thousand for a young female to a few million for females older than 10 years.

Since spawning is regulated to a large degree by water temperature during the April–June period, the time of peak spawning varies from year to year and may show several peaks within a year. Spawning may also be limited by salinity; most spawning occurs at salt concentrations of less than 200 mg/l total dissolved solids (TDS).

The female broadcasts the eggs into the water, and after fertilization by the male, the developing embryos drift with the current. After hatching from the egg, the larvae are small (3–5 mm) and depend on food originally available in the egg. Mortality from all sources during this period is very high, at times in excess of 50 percent per day. The larvae begin to feed at the 5–7 mm stage (about 10 days to 2 weeks after fertilization). Survival at this time may depend on whether the larvae are transported to an area where food of the right size and concentration is available. Larval bass initially depend on small crustaceans (part of the zooplankton) for food. As the bass grow, they are able to capture larger zooplankton, such as the mysid shrimp (*Neomysis mercedes*) and later small fish.

By the end of July, the juvenile bass have grown to the 30–40 mm size range and are found mostly in the Delta, Suisun Bay, and Montezuma Slough (in Suisun Marsh). Most of the young bass remain in the upper estuary (San Pablo Bay through the Delta) during their first two years of life.

Environmental Concerns. Water management in the Delta presents several problems to the survival and maintenance of the striped bass resource. These problems may be related to:

1. ***Using Delta channels for flood control and as conduits to transport water from the Sacramento River across the Delta to the export pumps of Reclamation and DWR.*** The Delta is an important spawning and nursery area, but water project operations cause the net direction of flow to reverse from the norm in west and south Delta channels. In addition, the Delta Cross Channel diverts water into the Central Delta. Many striped bass eggs, larvae, larger young, and their food organisms can become entrained in these reverse flows and, thus diverted from their normal migratory paths and nursery. In addition, water project operations may increase flow velocities in the major transport channels, reducing water residence times and perhaps the production of invertebrates, which young bass eat.
2. ***Entrainment of young fish and their food supplies in the SWP and CVP diversions and agricultural and industrial diversions.*** Striped bass eggs, larvae and juveniles are removed from the Delta channels and Suisun Bay through various diversions. These young striped bass are lost to local agricultural diversions when Delta islands are irrigated or flooded for leaching. They are lost at Antioch and Pittsburg, where Delta water is pumped for PG&E powerplant cooling systems.

   Some young striped bass are pulled into the forebay, where predation, fish screens, handling, and hauling cause losses. Other young striped bass are pumped into the SWP and CVP water transport systems, where they support a striped bass population in both San Luis Reservoir and the California Aqueduct. In each case, the young striped bass entrained are considered total losses to the potential Delta striped bass population.
3. ***The amount of outflow present to transport young fish away from water diversions in the Delta and to maintain the striped bass nursery and the entrapment zone in Suisun Bay, where it is most productive.*** Striped bass eggs and larvae, drifting with the current in the lower Sacramento and San Joaquin rivers depend on the downstream movement of water to transport them to Suisun Bay, where conditions may be suitable for their growth and survival. The same moderately high outflows necessary to transport young bass downstream may also enhance production of their food organisms by keeping the entrapment zone in Suisun Bay.
4. ***Salinity intrusion.*** Striped bass require water that is fresh or only slightly saline in which to spawn. In the Delta, spawning occurs mainly in the San Joaquin River from Antioch to Venice Island. Salinities in that reach are lowest just downstream from the mouth of the Mokelumne River. Here fresh water from the Mokelumne and Sacramento systems dilutes the water from the upper San Joaquin River, which is saltier because of agricultural return flows. Farther west, the river gradually becomes more saline due to the intrusion of ocean water.

   Bass apparently react to this salinity regime while on their spawning migration. They generally do not migrate up the San Joaquin River beyond the point where salinity exceeds 350 mg/l TDS (550 electrical conductance [EC]). In relatively dry years, this salinity blockage occurs a few miles upstream from Venice Island. Typically, spawning occurs between Antioch Point and Venice Island, where TDS is less than 200 mg/l (310 EC), but water that fresh is not essential for egg survival. Laboratory studies have indicated that salinities up to 1,000 mg/l TDS (1560 EC) do not affect egg survival.

Whereas salinity up to 1,000 mg/l TDS apparently does not increase egg mortality and has, at most, a limited short-term effect on the location of spawning, the long-term effect of salinities above 200 mg/l TDS is uncertain. Striped bass have a pronounced tendency to return to the same spawning area each year and occasional less-than-optimum salinity conditions may not deter this migration.

SWRCB Decision 1485 salinity standards protect striped bass spawning in the west Delta. The spawning standards (salinities and minimum Delta outflows) are effective April 1 through May 5; the survival standards (minimum Delta outflows) are effective May 6 through July 31. These standards have a relaxation provision when the projects impose deficiencies in firm supplies. These deficiencies occur when, due to a water supply shortage, water users are denied the full amount of water that they would otherwise be entitled.

Status of the Stock. Indices of striped bass abundance have been obtained at the egg and larval stage, at 38 mm, during the fall and early winter of their first year of life, and as adults on their annual spawning migration. The period of record for the four indices is variable, with the longest period of record being for the 38 mm index (also called the townet index), the fall index (also called the mid-water trawl index), and adult population size and age distribution. The discussion of trends in abundance focuses on these three indices.

The townet index is designed to represent the number of striped bass in the upper estuary when the average size of the juveniles collected is 38 mm. Sampling limitations such as the use of less than 100 percent efficient nets, patchiness, and annual fluctuation in spatial distribution are severe enough to prevent the calculation of absolute numbers of juvenile striped bass. Nevertheless, the townet index provides a good relative measure of abundance of each year class to 38 mm. In extremely wet years, such as 1983, the index is probably biased low since flows may wash many small bass downstream of the sampling area.

The townet index has varied from a low of about 4 in 1990 to a high of about 117 in 1965 (Figure 5-9). The 1976-77 drought seems to coincide with a break in the curve, with the pre-1977 index averaging about 67 and the post-1977 index (through 1990) averaging about 21. Since the drought, only 1986 resulted in a year-class comparable to those in the 1960s and early 1970s. These data demonstrate that the number of juvenile striped bass has been much lower during the past decade than before the 1976-77 drought.

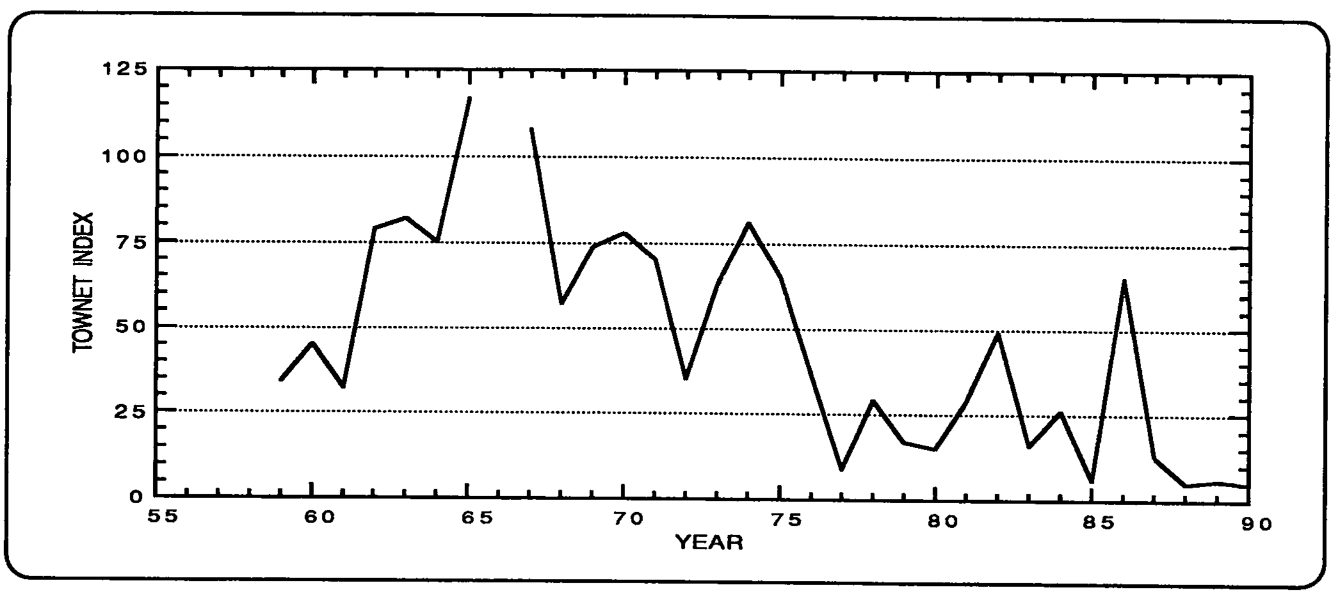


Figure 5-9. Striped Bass Summer Townet Index, 1959-1990

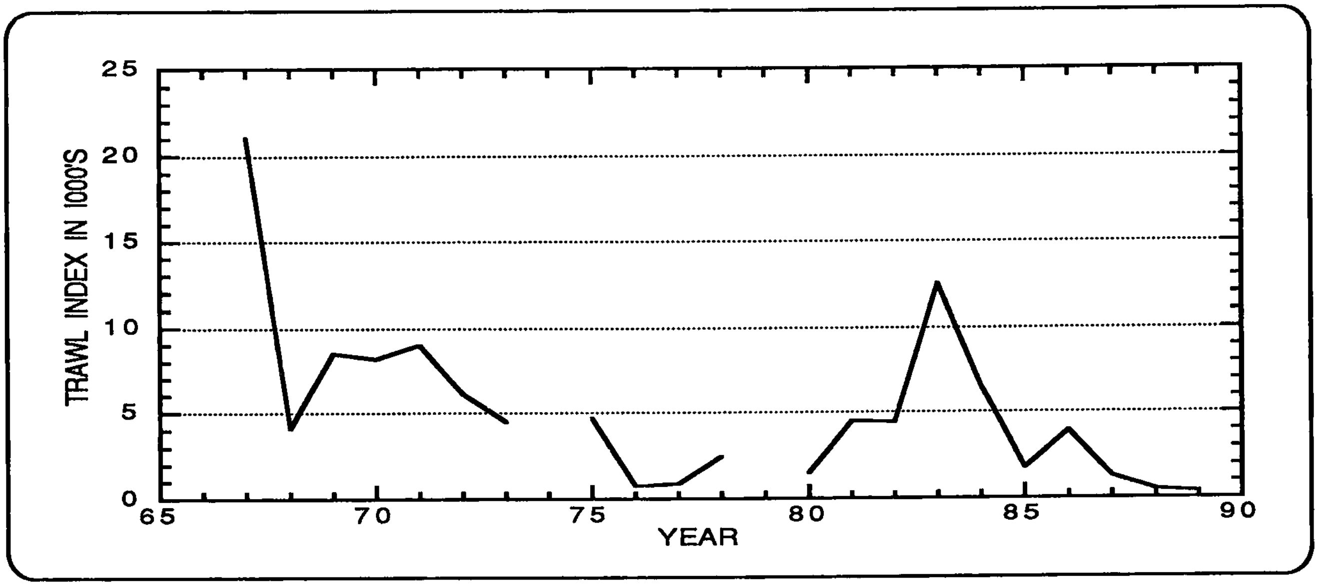


Figure 5-10. Fall Total Mid-water Trawl Striped Bass Index, 1967-1989

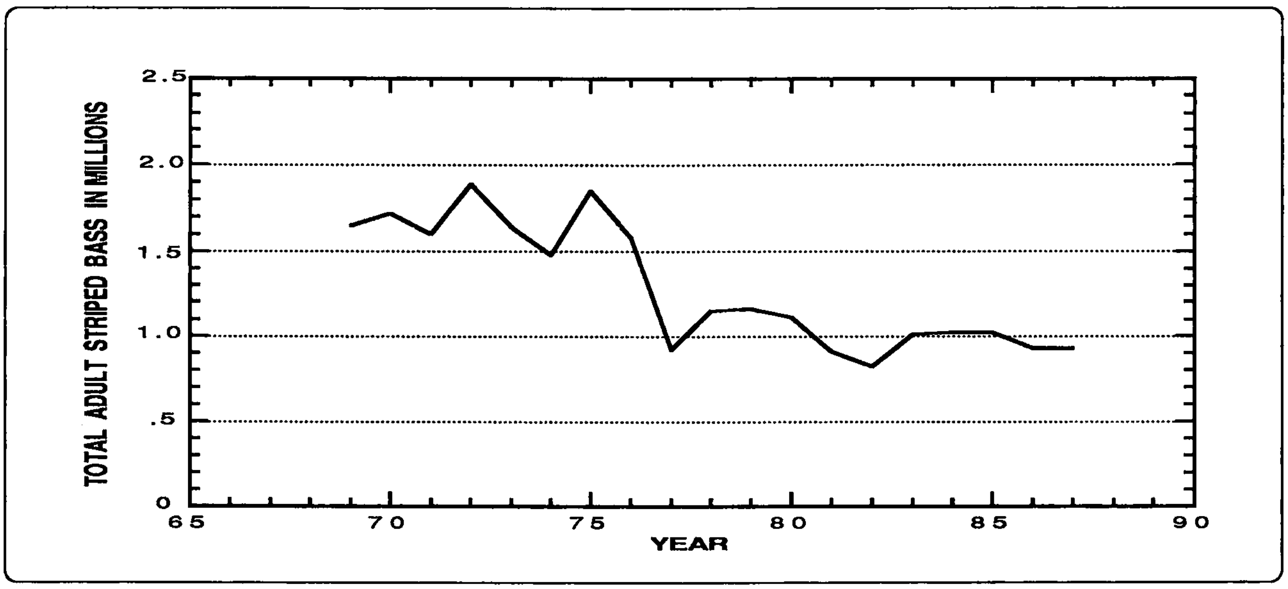


Figure 5-11. Total Number of Adult Striped Bass 1969-1987 as Estimated by the Peterson Mark-Recapture Method

The total fall mid-water trawl indices from 1967 through 1989 are plotted in Figure 5-10. Individual indices are determined for the months of September, October, November, and December; however, only the total index is plotted. This index cannot be numerically compared with the townet survey index since the collection and computational methods are different. Although numerically larger, the fall index represents fewer fish due to substantial mortality between summer and fall surveys. The fall index is more erratic than the townet. However, like the townet index, after 1977, the fall index has been about half of what it was before the drought.

Another index of striped bass abundance is obtained as the adult bass migrate up the Sacramento and San Joaquin rivers on their spawning runs. Adult fish are captured by nets and traps, and tags are applied to fish of legal size. Also, age of the fish is determined by analyzing growth rings on their scales. Through creel census and subsequent tagging operations, some tagged fish are recovered.

By use of computations involving the number of tags applied, the number recovered, and the ages of the tagged fish (plus several assumptions), an annual age-specific estimate of the adult population size is obtained. Because of sampling problems (especially related to low numbers of tags applied to older fish), these estimates have fairly large margins of error.

As shown in Figure 5–11, the adult striped bass population was relatively stable at about 1.5 to 2 million fish from 1969 through 1976. In 1977 the population appeared to drop precipitously to about 1 million fish and again has remained fairly stable. Given the wide variability before and after 1976, it is impossible to determine if there was actual year-to-year variation in numbers of fish. There is no doubt, however, that there have been significantly fewer adult fish since 1977 than there were in the early 1970s.

Factors Controlling Stock Size. In 1987, several agencies submitted evidence to the SWRCB concerning the striped bass decline and factors that may control their distribution and abundance at different life stages in the Bay/Delta.

Important points are listed below:

- ***Delta Outflow and Diversions.*** Prior to 1977, a regression equation developed by DFG explained most of the annual variation in the summer townet index. Most of the variability in this equation, can be explained by outflow at Chipps Island during May and June and the percentage of Delta inflow diverted by the SWP, CVP, and local Delta agriculture. Figure 5–12 contains a plot of the measured abundance index and the index predicted by the regression.

  After 1976 (with the exception of 1986), the regression equation consistently overestimates the number of young yearling striped bass (Figure 5–12). (The 1983 year class should not be considered in this comparison, because high spring flows washed fish out of the sampling area.)

  The data indicate that some fundamental change in system productivity may have occurred after the 1976–77 drought because flows and diversion rates similar to those before the drought do not result in as many fish.

- ***Food Supply.*** One possible explanation for recent low production of juvenile striped bass is that there may be less total food or less high-quality food available for the larval and juvenile bass. This hypothesis is supported in part by the following general observations:

  (1) Since 1976, there has often been lower algal standing crop in such striped bass nursery areas as Suisun Bay and the central, west, and south Delta. However, as yet there has been no relationship demonstrated between the algal standing crop and striped bass year-class strength.

  (2) Since 1976 many of the Delta phytoplankton blooms have been dominated by a chain diatom, *Melosira granulata*, which may not be as available for use in the striped bass food web as previously dominant algal species. However, there is no strong evidence to show that increased *Melosira* abundance has re-

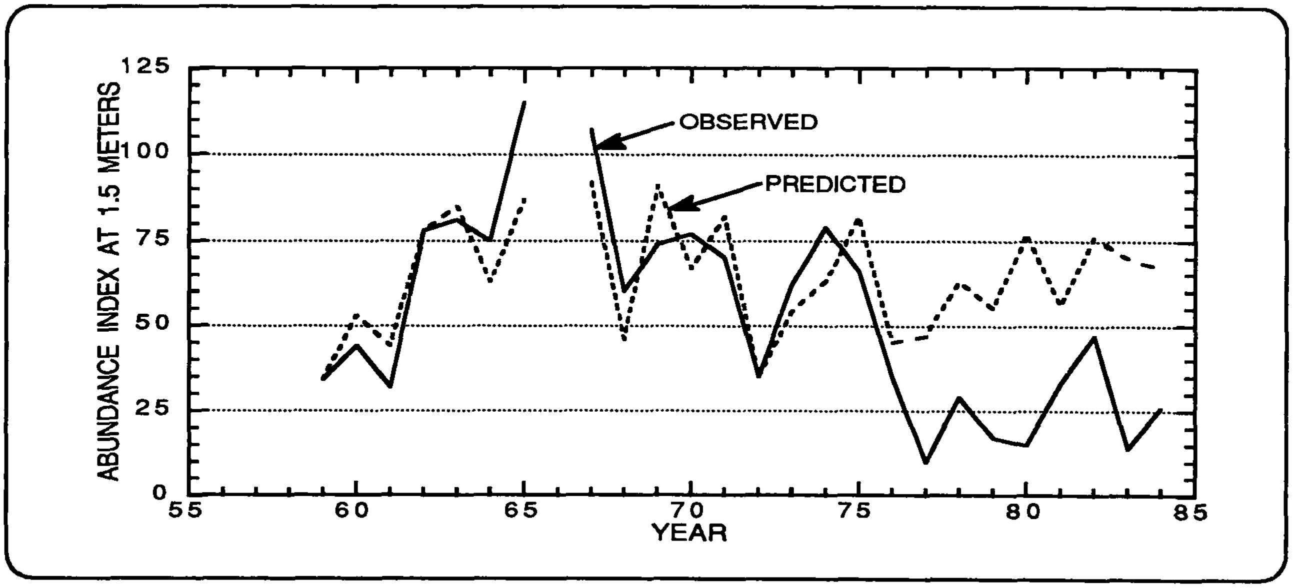


Figure 5–12. Observed and Predicted Indices of Striped Bass Abundance at 1.5 Meters, 1959–1984

stricted the food supply available to young striped bass.

(3) Several introduced species of invertebrates have recently become established in the Bay/Delta, which have either displaced other animals common in the diet of young striped bass or which may be competing with them for food. Two foremost examples of these accidental introductions, both from Asia, are a copepod, *Sinocalanus*, and a clam, *Potamocorbula. Sinocalanus* has apparently largely displaced a native copepod *Eurytemora*, which was extensively fed upon by larval striped bass (Figure 5-13).

Laboratory studies have shown that *Sinocalanus* is better able to avoid capture by young bass than *Eurytemora.* The small clam, *Potamocorbula,* was first observed in 1986 and appears to be dominating the bottom-dwelling community in San Pablo Bay, Suisun Bay, and the west Delta. This clam is an effective filter feeder and may be removing significant amounts of algae and zooplankton from the water column.

During the drought, USGS hypothesized that observed low algae and zooplankton in Suisun Bay and the west Delta was due to grazing by other clams, *Mya-arenaria* and *Macoma bathica,* which temporarily invaded Suisun Bay and the west Delta due to increased seawater intrusion. *Potamocorbul*a is tolerant of a wider salinity range and could become a permanent member of the benthic community, with long-term effects on production of pelagic fish, such as striped bass, in the system.

(4) Since the 1976-77 drought, *Neomysis*, a key food organism for striped bass (and other Bay/Delta carnivorous fish) has been found at generally low population levels (Figure 5-14).

The Interagency Ecological Studies Program has initiated studies that use such measures as daily growth rate, body measurements (morphometrics), and tissue development (histology) to assess the condition of young striped bass in the Sacramento-San Joaquin estuary. Preliminary results indicate that selected measures of morphology and histology of wild striped bass larvae do not significantly differ from well-fed hatchery striped bass. This indicates that the captured striped bass were apparently well fed in 1988. However, starved bass may have died and were not available to be captured in the field program. A wider variety of sites were completed in 1989; however, the data are not yet available.

DFG reported that there is some evidence that adult striped bass from the estuary are not food limited, or at least that the adults captured do not exhibit symptoms associated with insufficient food.

In summary, there is some evidence indicating that food supply may be limiting survival of larval and juvenile striped bass. However, there is no direct evidence that such limitations have actually affected the

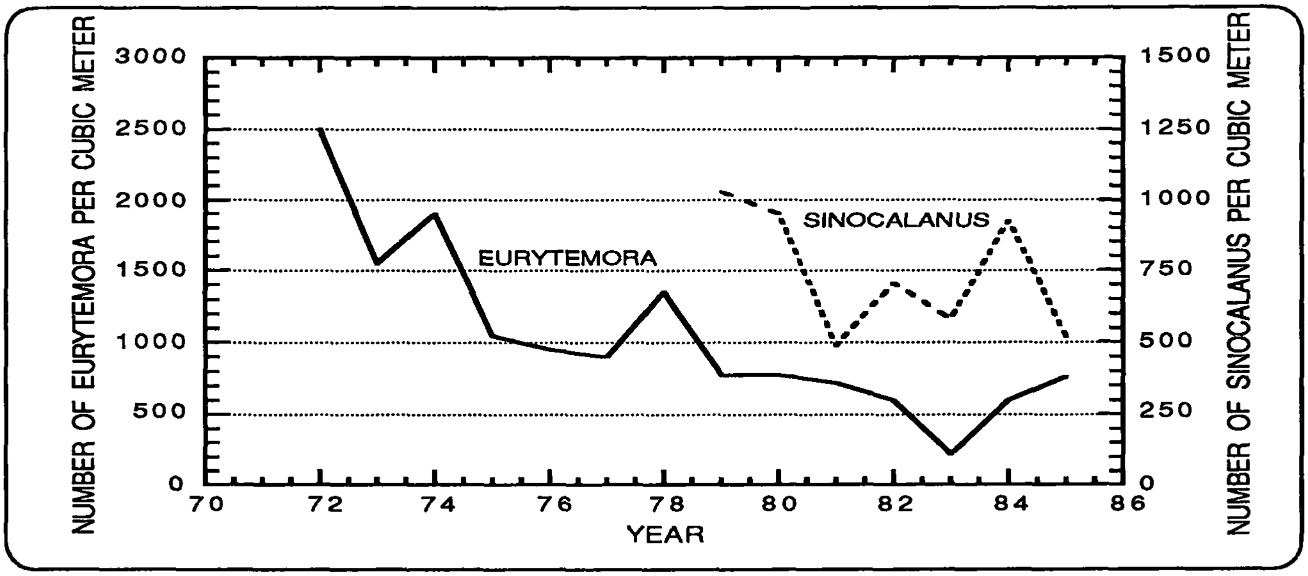


Figure 5-13. Densities of Eurytemora and Sinocalanus, All Areas, 1972-1985 (Adopted from DFG, 1987)

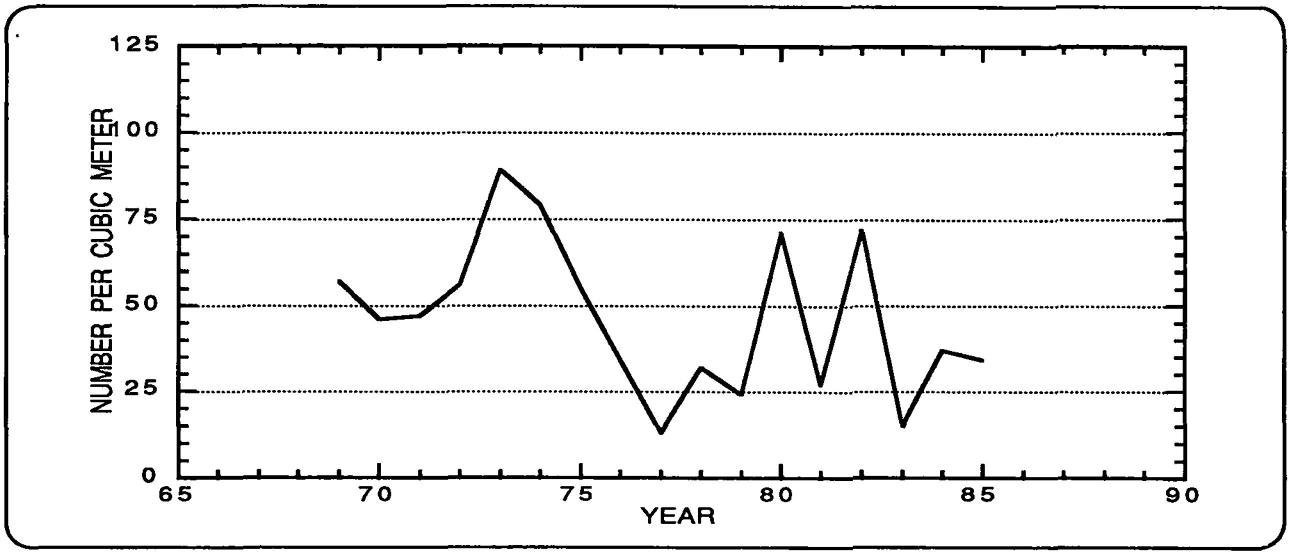


Figure 5–14. Mean March–November *Neomysis* Abundance from western Suisun Bay to Rio Vista on the Sacramento River, and to the mouth of Old River on the San Joaquin River, 1969–1985. Adapted from DFG 1987b

ability of striped bass to survive during their first few weeks.

- *Egg Supply.* One explanation for low indices of juvenile abundance since the 1976-77 drought has been the lack of eggs to "saturate" the environment. According to this theory, when conditions are optimum, good year classes are produced because egg supply is not limiting. In a system with less than optimum environmental conditions and high larval mortality, a larger egg supply is needed to ensure that enough juveniles remain after the period of high initial mortality to produce a good year class. The egg limitation hypothesis is supported by the lower adult population abundance since the drought and the sharply reduced numbers of older, highly fecund, females in the population. Because of these two factors, the present egg supply is probably less than one-third of that found in the early 1970s.

  That the present striped bass population can produce a relatively strong year class, given adequate environmental conditions, was demonstrated in 1986. The 1986 townet index was about 65, the best since the drought and similar to those produced before the drought with the same general environmental conditions. This good year class was in spite of the fact that there was no apparent change in numbers of spawners in 1986.

- *Adult Mortality.* Adult mortality is assumed to occur after striped bass reach legal size and may be characterized as fishing and natural mortality. Natural mortality includes those adult fish dying from old age, disease, poaching, and toxics. Fishing mortality includes legal and some illegal take by anglers. The total annual mortality of adult striped bass in the Bay/Delta system has shown an upward trend from 1969 through 1984 (Figure 5–15). This upward trend is due to higher mortality of those fish 5 years and older (Figure 5–15), with mortality of 3- and 4-year-old fish being relatively stable at about 50 percent.

  Although total annual mortality exhibited an upward trend, the expected similar trend in either natural mortality or legal take did not occur (Figure 5-16). DFG believes that the striped bass populations should be able to sustain the 15 to 30 percent harvest rate found in the Sacramento-San Joaquin system.

  Although overall fishing mortality is relatively low compared to values for other populations such as in Chesapeake Bay, there has been a decrease in the average age of Bay/Delta striped bass population. One result of decrease in average age is that the population now contains a significantly lower percentage of older females (7 years old and older) than it did in the early 1970s. Fish 7 years and older averaged 13 percent during the 1969 through 1976 period, compared to an average of 5 percent in the 1977 through 1987 period. As mentioned earlier, the older larger females carry relatively more eggs than younger ones. Thus, the combined effect of lower overall population, plus the decrease in older females, is to cause a greater loss of egg

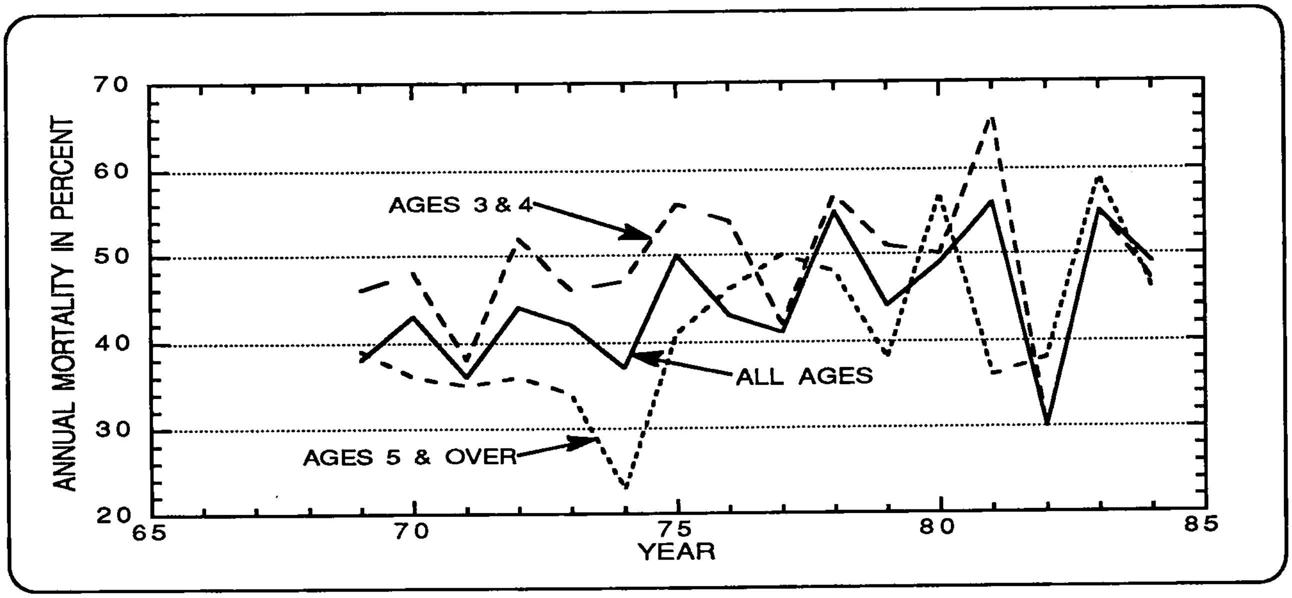


Figure 5-15. Estimates of Total Annual Mortality Rates for Striped Bass in the Sacramento-San Joaquin Estuary from 1969-1984

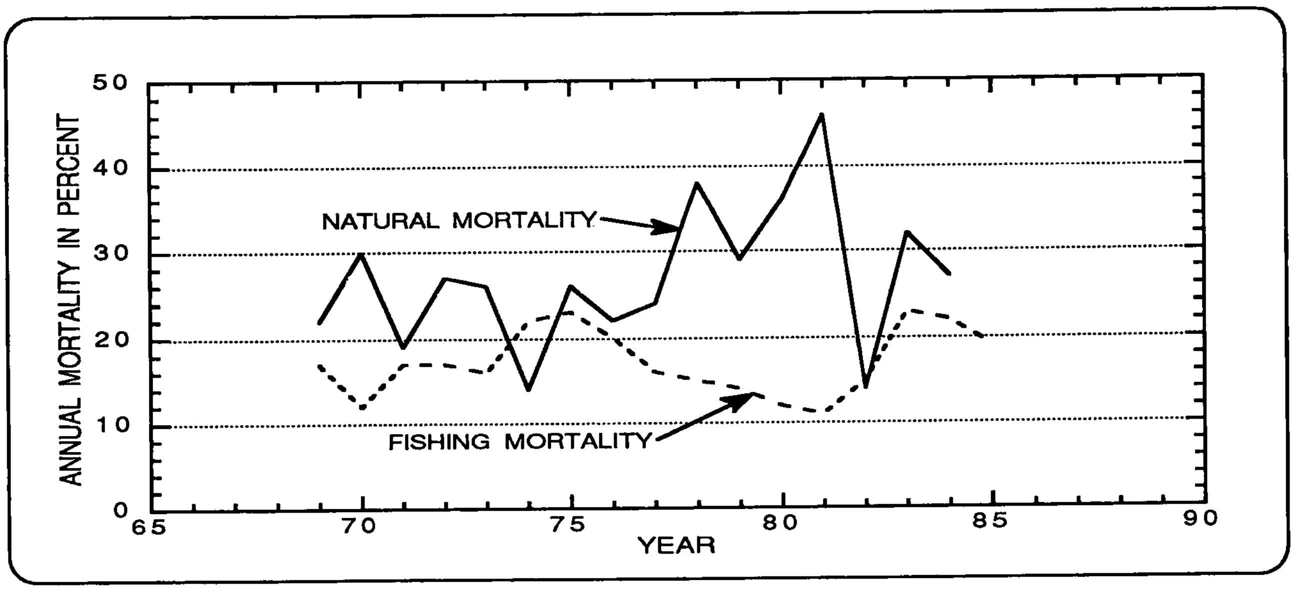


Figure 5-16. Estimates of Fishing and Natural Mortality Rates for Striped Bass in the Sacramento-San Joaquin Estuary from 1969-1984

production capacity than would be indicated by population numbers alone.

- *Toxics*. The Bay/Delta and its surrounding watershed receive treated and untreated waste water and point and nonpoint runoff from urban areas, mines, and agricultural lands. These waters often contain materials such as trace metals, pesticides, and organic materials that can potentially adversely affect the survival of striped bass and their food organisms.

Studies by the National Marine Fisheries Service (NMFS) conducted in the late 1970s and early 1980s indicated that striped bass in this estuary exhibited symptoms typical of those induced by pollutants. These symptoms included high egg resorption rates and the presence of extensive parasite infections. Adult striped bass from the Bay/Delta were generally found to be in poorer health than fish of similar age and sex collected in Oregon, Lake Mead, or the East Coast. Unfortunately, changes of program priority within NMFS resulted in their research being terminated before the necessary cause–effect studies were completed.

A Citizens for a Better Environment report *Toxic Hot Spots in San Francisco Bay*, August 1987, identified 39 toxic hot spots where toxic chemicals have reached threatening levels in the sediments, shellfish, ducks and waters of the San Francisco Bay estuary. The report states:

> ". . .The toxic hot spots pose serious, poorly controlled risks to aquatic life and human health, and are adversely affecting the beneficial uses of Bay waters. Pollutants such as pesticides, petrochemicals, PCBs, selenium, mercury and other toxic heavy metals exceed available environmental health effects criteria or standards at the identified toxic hot spots. At some sites, toxic pollutants have bioaccumulated in edible shellfish to levels amongst the highest detected in any estuary in the world. At some sites, the toxicity of Bay sediments to aquatic organisms has been demonstrated by laboratory tests, and field studies have documented localized biological degradation."

The report went on to recommend that fresh water diversions be evaluated and modified to reduce the potential for toxic hot spots to increase, especially in the South Bay. DWR believes that any dependency on outflow to control toxics is not only ineffective but also of questionable legitimate beneficial use. High flows do dilute pollutants in the Bay. However, minimum summer flows, with or without fresh water diversions dilute pollutants in San Francisco Bay very little. Low flows continue for a long enough period in most years for an equilibrium to be established between pollutant concentrations and dilution due to tidal action. Adequate quality at that equilibrium depends on sufficient waste treatment, not on fresh water flow levels. The South Bay in particular is hydraulically isolated from flows, to control pollution during much of the year. San Francisco Bay receives large inputs of ocean water (approximately 2.1 million cfs during flood tide).

DFG, with technical assistance from NMFS and financial support from the SWRCB, has carried on a limited version of adult striped bass "health" monitoring. The present monitoring consists of collecting 40 adult pre-spawning females from the Sacramento and San Joaquin Rivers (20 each) and analyzing them for a variety of chemical residues and measurements of egg resorption, parasite infestation, length, and weight. In their 1987 progress report, DFG staff concluded:

(1) The health of the Bay/Delta striped bass population is being impacted by toxics.

(2) Egg resorption rates may still be at levels that adversely impact egg production.

(3) Research to date has not been able to draw strong direct relationships between specific pollutants and striped bass health.

(4) The health monitoring program should be thoroughly reviewed and restructured so that it will more effectively index striped bass health and lead on to cause–effect relationships.

The report also recommended that only limited field sampling and analysis be conducted in 1989 so that time would be available for program review. DFG has assembled a panel of outside experts to help in this review.

The Central Valley Regional Water Quality Control Board has recently released results of toxicity bioassays, which indicate that the Colusa Basin Drain and other agricultural and municipal drains may be discharging materials to the Sacramento and San Joaquin rivers that makes them acutely toxic to striped bass and fathead minnow larvae, an invertebrate (*Ceriodaphnia*), and algae.

Although the extent to which toxic substances may contribute to the continued decline of striped bass has not been determined, there is reason for general concern in this area.

- ***Spawning Habitat.*** There is no evidence that spawning habitats have been damaged. SWRCB standards have sufficiently protected them.
- ***Larval Survival Rates.*** The rate at which striped bass survive their first few months is critical to subsequent juvenile bass abundance. Larval bass survival varies greatly from year to year. Years that have produced the least fish have also had extremely low survival of larvae. The cause is not yet known.

- *Entrainment.* The Sacramento–San Joaquin Delta, the lower San Joaquin River, and Suisun Bay have numerous diversions that can entrain striped bass eggs, larvae, and juveniles. Following are the major diversions causing entrainment losses, along with a brief description of any fish protection facilities, and where possible, some idea of the actual numbers lost.

(1) State Water Project. SWP presently diverts up to about 6,400 cfs of water from the south Delta near the town of Byron. Extensive fish protective facilities have been constructed to minimize fish losses. Figure 5-17 is a plot of the total numbers of striped bass collected at the Skinner Fish Facility during 1968 through 1989. These screens are not effective for striped bass less than about 20 mm long; in 1985, 1986, 1987, 1988 and 1989, separate surveys were made to estimate losses at these stages. At the SWP intake, estimated losses of striped bass eggs and larvae less than 20 mm long (converted to yearling equivalents) were:

1985 - 68,488

1986 - 37,109

1987 - 43,846

1988 - 59,625

1989 - 56,309

The analysis of direct impacts, discussed later in Chapter 5 under "Direct Impacts of the Delta Complex on Striped Bass, Including Eggs and Larvae," includes a more detailed description of all striped bass losses at the intake to Banks Pumping Plant and a description of the agreement to offset the impacts. DWR is raising and releasing bass to offset losses at the Banks Pumping Plant.

SWP recently began diverting about 120 cfs out of Barker Slough in the north Delta. This diversion was not in effect during the period of decline. State-of-the-art fish screens (wedge wire with 5/32-inch openings) were installed to protect juvenile striped bass and other fish. Surveys have shown that very few striped bass eggs and larvae are found in this area.

(2) CVP intake near Tracy. The CVP has the capacity to divert up to 4,600 cfs from the south Delta. The screening system is similar to that used by SWP except that the primary system is one long louver instead of a series of bays. Striped bass salvage for 1968–1988 is shown in Figure 5-18.

(3) Contra Costa Canal. The Contra Costa Canal diverts an average of about 200 cfs through an unscreened intake near Rock Slough. DFG estimated that as many as 5 million young-of-the-year striped bass were entrained in the Contra Costa Canal during 1972 and 1973.

(4) Delta Agricultural Diversions. There are approximately 1,800 small agricultural diversions, which take about 3,000 to 4,000 cfs of water from Delta channels during spring and early summer, when striped bass eggs and larvae are most vulnerable to entrainment. None of these diversions is screened or otherwise operated to prevent or minimize entrainment.

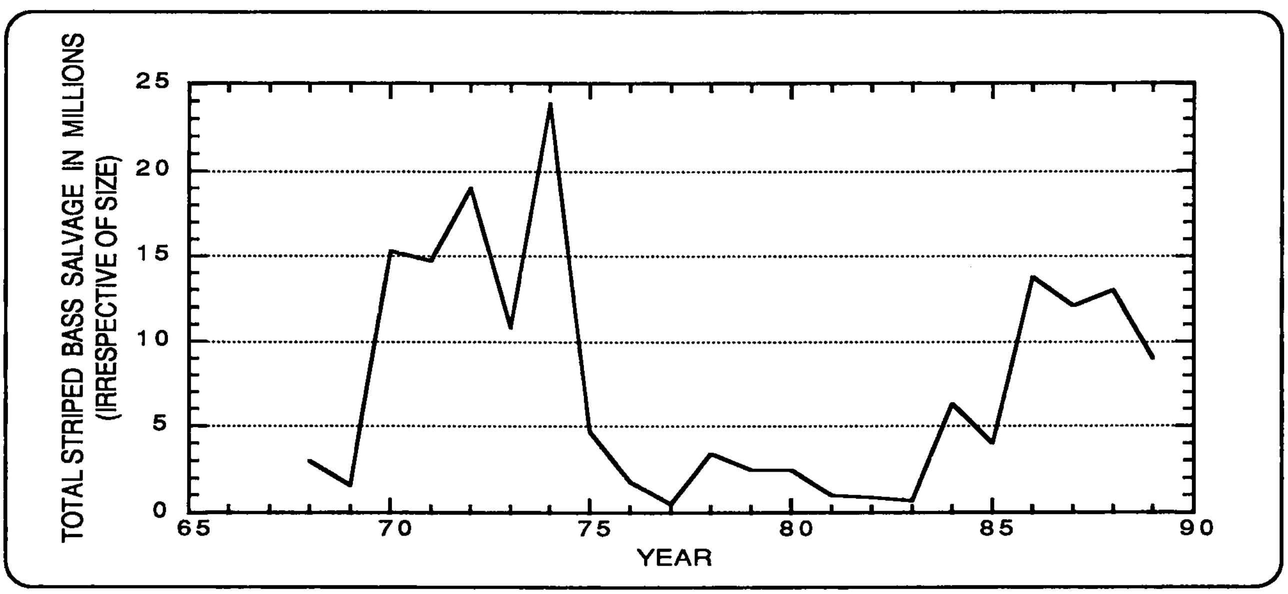


Figure 5–17. Striped Bass Salvage at the Delta Intake to the SWP, 1968–1989

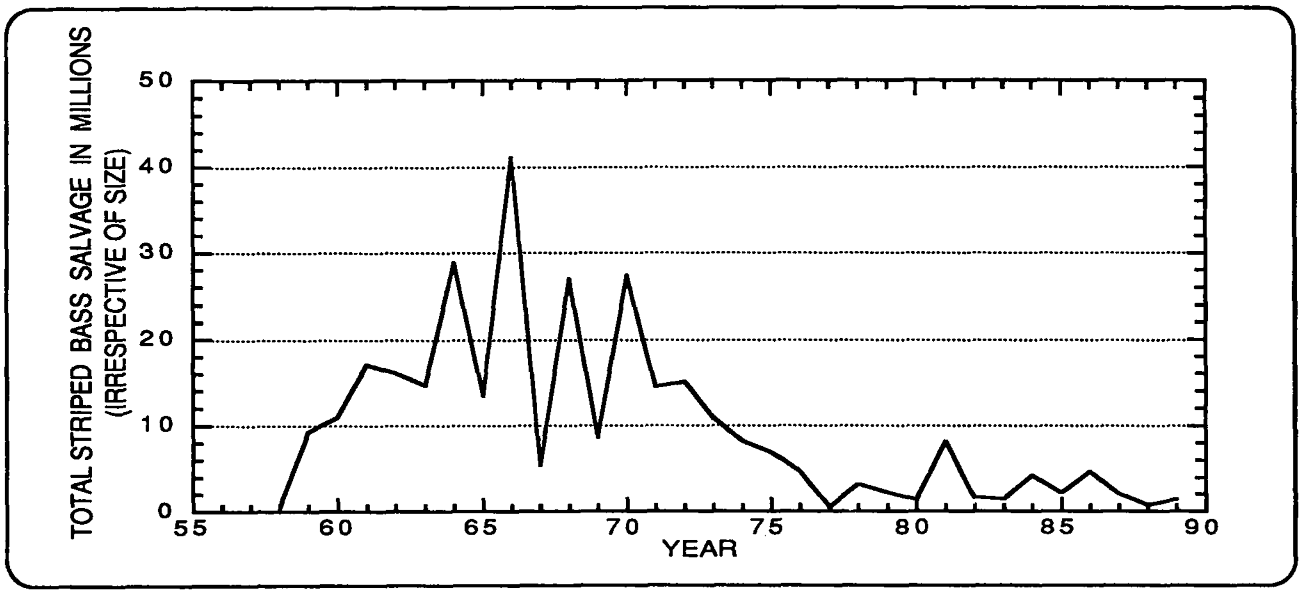


Figure 5-18. Striped Bass Salvage at the South Delta Intake to the CVP, 1958–1989

Although reliable numbers of striped bass lost to the Delta agricultural diversions are difficult to obtain, DWR estimated that 1978 and 1979 egg and larval losses to such diversions were about 600 million per year, or about the same order of magnitude as those lost to SWP and CVP diversions.

(5) Pacific Gas and Electric (PG&E). PG&E operates two power plants (Antioch and Pittsburg) which divert cooling water from the striped bass nursery area. Juvenile striped bass entrained in these intakes can be killed due to temperature changes. Between March 1978 and March 1979, it was estimated that about 144 million striped bass were entrained and killed by the Pittsburg Power Plant. Fewer striped bass were lost through the Contra Costa Power Plant. Recent changes in operation plus lower striped bass abundance have apparently reduced these losses considerably. PG&E is releasing hatchery-produced bass to offset losses at the facilities.

(6) Miscellaneous Other Diversions. In addition to diversions for Delta agriculture, water is diverted at numerous locations in and below striped bass spawning areas in the Sacramento and lower San Joaquin rivers for agricultural, municipal, and industrial uses. There has been no analysis of the numbers of striped bass lost to these diversions. In 1990, DFG will initiate a major study of unscreened diversions in the Central Valley, with particular reference to salmonid. Information in this study may also be relevant to striped bass.

(7) Delta Cross Channel and Georgiana Slough. Although not a diversion in the typical sense, the diversion of water from the Sacramento River to the interior Delta via the Delta Cross Channel and Georgiana Slough has the potential to adversely impact striped bass. This conclusion comes from analyses showing that in recent years the Delta has become a less hospitable nursery area for young striped bass. It appears that projects resulting in more eggs and larvae drawn to the Delta could adversely impact year-class strength.

As is apparent from the preceding discussion, hundreds of millions of juvenile striped bass are lost annually to diversions from the Sacramento River, the Delta, and Suisun Bay. The impact of these losses on adult population numbers is difficult to determine. Because striped bass are prolific spawners, the species has evolved in a manner that allows for over 99 percent mortality between eggs and adults while still maintaining a level population.

Some mechanism is probably present to maintain adult population stability in spite of variations in year class strength since there is an apparent lack of correlation between the 38 mm index and subsequent abundance of 4 year olds from the same year class (Figure 5-19). This differentiation between juvenile and adult abundance is also demonstrated by the indices themselves; i.e., the 38 mm index varied about tenfold (from 117 to 9) during 1965 through 1983, whereas the popu-

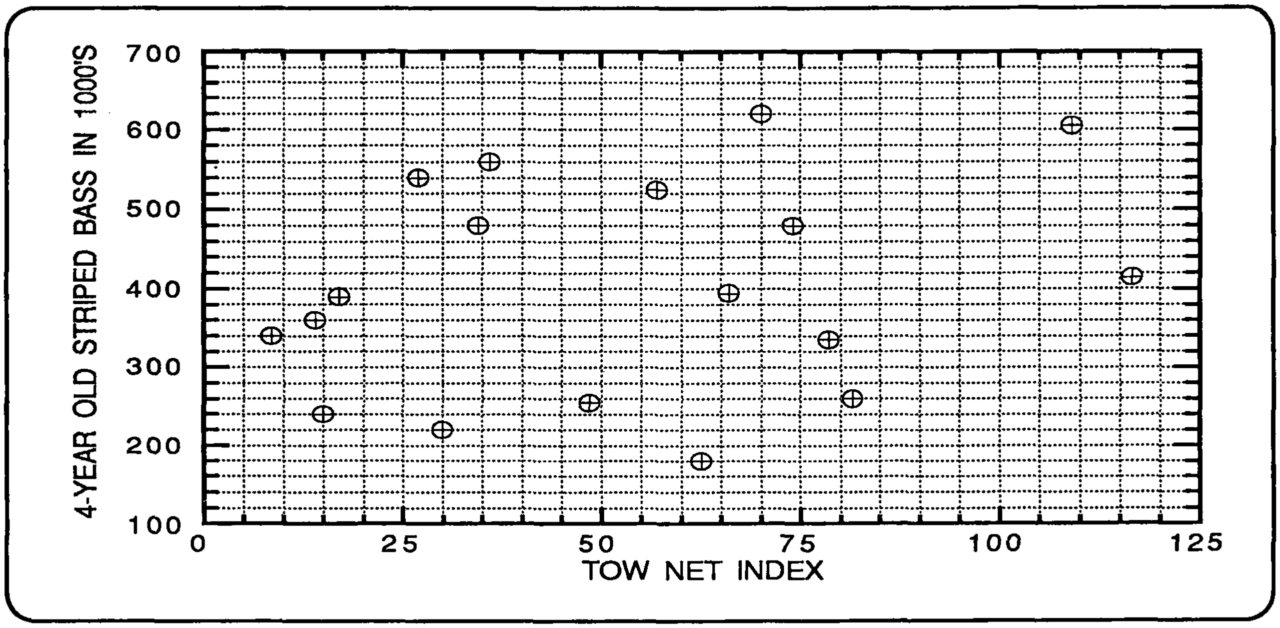


Figure 5-19. Townet Index vs Subsequent Number of 4-year-old Adult Striped Bass

lation of 4 year olds only varied by a factor of 3 (from about 600,000 to 200,000).

Although the 38mm index is not correlated to the subsequent abundance of 4-year-olds from the same year class, DFG has found that it is closely correlated to an index of the abundance of 4-year-old bass. Fishery biologists do not agree on which of these two methods better reflect the relationship between the abundances of 38 mm and adult striped bass.

The above discussion does not mean that juvenile production is unimportant to adult striped bass abundance. DFG believes that entrainment losses are having an impact on egg production through cumulative effects on the numbers of adults.

Impacts of NDP. Uncertainties about factors affecting striped bass complicate analysis of the striped bass impacts associated with the change of export pumping and Delta flow and salinity patterns caused by the NDP alternatives. Impacts on the food supply for young striped bass cannot be analyzed completely because information and understanding are lacking.

Important factors that could be quantified and that were considered in the analysis of general impacts on young striped bass survival and abundance under the NDP alternatives follow:

1. Salinities (TDS) in the west Delta during spawning (April and May). High salinities could be detrimental to spawning and egg survival. The D-1485 water quality standards to protect striped bass spawning call for specific conductance not to exceed 0.550 mmhos during April 1 to May 5 at Prisoner's Point on the San Joaquin River. This standard equates to approximately 350 mg/l total dissolved solids (TDS).

Table 5-21 summarizes monthly average salinities at Antioch and Prisoner's Point in the San Joaquin River for the five water years chosen out of the 57-year study period to be representative of each water year classification.

2. Flows in the lower San Joaquin River during May, June, and July. Reverse flows in the lower San Joaquin River can adversely affect striped bass by pulling eggs, larvae, and juveniles from the Sacramento River and Suisun Bay toward the Delta. Once in the Delta, these life stages are subject to increased diversion by local agricultural intakes and by the State and federal pumps.

Table 5-21
Mean Monthly Salinities in Lower San Joaquin River During Striped Bass Spawning
For the Five Representative Water Years
(Values in milligrams per liter of total dissolved solids)
[3.8 MAF SWP Demands]

San Joaquin River at Antioch

	Critical		Dry		Below Normal		Above Normal		Wet	
Alternative	**April**	**May**	**April**	**May**	**April**	**May**	**April**	**May**	**April**	**May**
1	1,224	1,310	486	269	226	205	84	85	112	101
2A	1,336	1,174	449	213	174	159	84	85	112	102
2B	1,170	896	269	157	145	140	84	86	101	90
3A	1,336	936	449	213	174	159	84	85	112	102
3B	1,226	936	312	165	143	147	84	85	113	99
4A	1,336	1,174	449	213	174	159	84	85	112	102
4B	1,226	936	312	165	143	147	84	85	113	99
5A	1,336	1,174	419	213	174	159	84	85	112	102
5B	1,226	936	1312	165	143	147	84	85	113	99
6A	1,170	896	269	157	145	140	84	86	101	90
6B	1,226	936	312	165	143	147	84	85	113	99

San Joaquin River at Prisoners Point

	Critical		Dry		Below Normal		Above Normal		Wet	
Alternative	**April**	**May**	**April**	**May**	**April**	**May**	**April**	**May**	**April**	**May**
1	95	93	86	86	84	86	82	83	142	98
2A	95	94	84	88	83	89	82	86	137	100
2B	91	96	84	91	85	92	80	85	34	94
3A	95	94	84	88	83	89	82	86	137	100
3B	88	89	82	86	82	87	81	83	148	98
4A	95	94	84	88	83	89	82	86	137	100
4B	88	89	82	86	82	87	81	83	148	98
5A	95	94	84	88	83	89	82	86	137	100
5B	88	89	82	86	82	87	81	83	148	98
6A	91	96	84	91	85	92	80	85	134	94
6B	88	89	82	86	82	87	81	83	148	98

Table 5-22 summarizes projected seasonal flows in the San Joaquin River at Antioch under the NDP alternatives. The two periods shown are May through July and August through November. The May through July period is most critical for the larval and early juvenile stages. During August through November, young-of-the-year are still subject to entrainment and reverse flows can contribute to increased entrainment losses.

3. Delta outflow and SWP exports in May, June, and July. During May, June, and July, striped bass eggs, larvae, and juveniles are probably most vulnerable to environmental stresses.

Table 5-23 summarizes May, June, and July Banks Pumping Plant diversions and April-July Delta outflow by Decision 1485 water year types over the 57-year study period for the No-action alternative

Table 5-22
Mean Monthly Flows in Lower San Joaquin River[1]
Affecting Striped Bass Spawning
For the Five Representative Water Years
(Values in cubic feet per second)
[3.8 MAF SWP Demands]

	Critical		Dry		Below Normal		Above Normal		Wet	
Alternative	**Aug–Nov**	**May–Jul**	**Aug–Nov**	**May–Jul**	**Aug–Nov**	**May–Jul**	**Aug–Nov**	**May–Jul**	**Aug–Nov**	**May–Jul**
1	530	-154	22	30	-628	134	-369	2,853	-77	2,480
2A	845	95	193	283	-332	542	50	3,423	72	3,296
2B	1,309	418	500	751	18	1,023	615	4,142	188	3,771
3A	845	95	193	283	-332	542	50	3,423	72	3,296
3B	1,439	538	612	880	78	1,156	728	4,232	204	3,900
4A	845	95	193	283	-332	542	50	3,423	72	3,296
4B	1,439	538	612	880	78	1,156	728	4,232	204	3,900
5A	845	95	193	283	-332	542	50	3,423	72	3,296
5B	1,439	538	612	880	78	1,156	728	4,232	204	3,900
6A	1,309	418	500	751	18	1,023	615	4,142	188	3,771
6B	1,439	538	612	880	78	1,156	728	4,232	204	3,900

[1]San Joaquin River at Antioch. Negative sign indicates reverse flows.

(Operation Study 423) without a SDWMP alternatives (Operation Studies 424–429)

.

4. Flows through the Delta Cross Channel and Georgiana Slough during May and June. There is some evidence that actions causing more bass to reach the central Delta can adversely affect the production of juvenile striped bass. During the past several years the central Delta has become a less hospitable nursery area for young striped bass. For example, during 1960 through 1965, the Delta contributed an average of about 60 percent of the juvenile striped bass index. Twenty years later, from 1980 through 1985, the average contribution by the Delta stations had dropped to less than 30 percent. It is not clear why the central Delta no longer produces as many juvenile bass as before.

Table 5-24 shows the monthly average May through July ratios of cross-Delta flows to Sacramento River flows (Delta Cross Channel and Georgiana Slough flows divided by Sacramento River flows) during the five representative water years.

There is disagreement whether changes in these conditions will significantly affect the numbers of adult striped bass in the Bay/Delta; however, these conditions are the ones most often included on lists of important factors for striped bass abundance. Where possible, the analysis includes information bearing on potential impacts of changes in Delta conditions on adult numbers. This analysis is limited to the impact of NDP. Possible cumulative impacts of other projects are described in Chapter 6.

Table 5-23
Banks Delta Pumping Plant Diversions and
Delta Outflow During Periods of Striped Bass Abundance
(Monthly average flows in cubic feet per second over 57-year study period)
[3.8 MAF SWP Demands]

Alternative[1]	Banks Pumping Plant			Delta Outflow			
	May	June	July	April	May	June	July
				With Existing South Delta Facilities			
				Critical Year			
1	1,576	1,177	1,148	4,779	4,550	3,858	4,160
2A	1,559	1,362	1,074	4,779	4,550	3,851	4,041
2B	1,644	1,453	1,056	4,779	4,550	3,850	3,955
3A	1,582	1,397	1,095	4,779	4,550	3,850	4,000
3B	1,650	1,459	1,069	4,779	4,550	3,850	3,955
4A	1,582	1,397	1,095	4,779	4,550	3,850	3,955
4B	1,650	1,459	1,069	4,779	4,550	3,850	3,955
5A	1,582	1,397	1,095	4,779	4,550	3,850	3,955
5B	1,650	1,459	1,069	4,779	4,550	3,850	3,955
6A	1,605	1,421	1,124	4,779	4,550	3,850	3,958
6B	1,650	1,459	1,069	4,779	4,550	3,850	3,955
				Dry Year			
1	2,431	2,000	3,787	8,396	7,579	6,262	6,152
2A	2,430	2,000	4,061	8,413	7,579	6,262	5,588
2B	2,429	2,000	4,247	8,340	7,579	6,262	5,661
3A	2,430	2,000	4,146	8,326	7,579	6,262	5,620
3B	2,429	2,000	4,258	8,347	7,579	6,262	5,666
4A	2,430	2,000	4,146	8,326	7,579	6,262	5,620
4B	2,429	2,000	4,258	8,347	7,579	6,262	5,666
5A	2,430	2,000	4,146	8,326	7,579	6,262	5,620
5B	2,429	2,000	4,258	8,347	7,579	6,262	5,666
6A	2,429	2,000	4,216	8,333	7,579	6,262	5,648
6B	2,429	2,000	4,258	8,347	7,579	6,262	5,666
				Below Normal Year			
1	2,432	2,000	4,337	9,083	9,664	8,433	6,879
2A	2,431	2,000	4,507	9,210	9,663	8,433	6,936
2B	2,430	2,000	4,575	9,170	9,663	8,433	6,991
3A	2,431	2,000	4,536	9,194	9,663	8,433	6,958
3B	2,430	2,000	4,579	9,154	9,663	8,433	6,993
4A	2,431	2,000	4,536	9,194	9,663	8,433	6,958
4B	2,430	2,000	4,579	9,154	9,663	8,433	6,993
5A	2,431	2,000	4,536	9,194	9,663	8,433	6,958
5B	2,430	2,000	4,579	9,154	9,663	8,433	6,993
6A	2,430	2,000	4,563	9,186	9,663	8,433	6,985
6B	2,430	2,000	4,579	9,154	9,663	8,433	6,993

Several NDP alternatives have been described in early sections of this report. The following discussion of potential environmental impacts on striped bass focuses on how the preferred and other alternatives compare to the No-action alternative. *No new fish screens are included in the preferred alternative or other alternatives in the analysis, and the operation of the Forebay is relatively unchanged from the present*. A more complete description of the preferred alternative is found in Chapter 3. Impact assessments for the preferred alternative and other alternatives, except entrainment losses, do not include projected water diversions for Los Banos Grandes and Kern Water Bank.

No-action Alternative. Engineering studies indicate that under the No-action alternative, striped bass spawning standards would be met in all years. In the Sacramento River, salinities are maintained during critical years by project reservoir releases. Striped bass in the Sacramento River spawn upstream of the salinity interface.

The lack of consensus regarding delineation of an entrapment zone precludes the use of Delta outflow values and surface salinity estimates to determine the location of the entrapment zone for the No-action alternative. It would presumably be the most beneficial to young bass if the entrapment zone consistently occurred within Suisun Bay during May through July; however, it is unknown how often this will occur.

Project Alternatives. The NDP alternatives would usually reduce salinity and the magnitude and frequency of reverse flow in the western Delta. Reducing salinity would increase spawning habitat for striped bass. More consistent downstream flow would reduce the number of young bass being pulled back upstream into the central and south Delta, where rearing habitat is of poorer quality and the fish are more susceptible to entrainment in diversion facilities. However, the project alternatives could also adversely affect the survival of young striped bass by increasing the proportion of young diverted from the Sacramento River into the interior Delta, by increasing entrainment, and perhaps by reducing Delta outflow in some months of critical and dry years.

Several measures are being considered in the Article VII negotiations to avoid, reduce, or mitigate the potential adverse effects of the NDP and other water project operations on Bay-Delta fish and wildlife. Among the measures being considered to protect striped bass are short-term closures of the Delta Cross Channel, modifying limitations on Delta exports, and changing minimum Delta outflow. Implementation of such measures could avoid or reduce the potential adverse impacts of the NDP on striped bass. The scope and status of these negotiations are described in more detail later in this report.

Table 5-21 shows that with the North Delta alternatives, Decision 1485 standards for striped bass spawning at Prisoner's Point would be met for all years. Generally, the NDP alternatives would substantially improve water quality for striped bass spawning in the western Delta in representative critical, dry and below normal years.

Table 5-22 shows that May-July flow in the lower San Joaquin River would be substantially higher with the North Delta Alternatives than with the No-action alternative. From August through November, flow in the lower San Joaquin River would also be higher with these three North Delta alternatives than with the No-action alternative. Higher flow would reduce the frequency and magnitude of reverse flow and thereby improve conditions in the western Delta for juvenile striped bass in the late spring and early summer during the critical time of bass spawning and larval abundance.

However, Table 5-22 also shows that with the North Delta project alternative, flow from August through November could be less than with the No-action alternative. Less flow and the more frequent flow reversals could worsen conditions for young striped bass later in the season.

Table 5-23 indicates that with existing South Delta facilities, SWP pumping from May through July of most years would be essentially the same with the six North Delta project alternatives as with the No-action alternative. However, pumping was greater with the North Delta project alternatives than with the No-action alternative in June of a representative critical year and in July of dry and below normal years. Less water was pumped in June of the critical year with the project alternatives.

Higher pumping would increase reverse flow in the South Delta, would increase entrainment in the SWP's pumps, and thereby could worsen conditions for juvenile striped bass. Less pumping would reduce reverse flow, decrease entrainment, and thereby could improve conditions for the juvenile bass. Direct losses of striped bass associated with the project and No-action alternatives are discussed further in this chapter under "Direct Impact of the Delta Complex on Striped Bass."

Table 5-23 also contains the projected Delta outflow at Chipps Island from April through July. Delta outflows

Table 5-24
Ratio of Cross Delta Flow[1] to Sacramento River Flow
For Months of High Young Striped Bass Abundance
For the Five Representative Water Years (3.8 MAF SWP Demands)

	Critical			Dry			Below Normal			Above Normal			Wet		
Alternative	**May**	**Jun**	**Jul**	**May**	**Jun**	**Jul**	**May**	**Jun**	**Jul**	**May**	**Jun**	**Jul**	**May**	**Jun**	**Jul**
No-Action	0.45	0.44	0.45	0.40	0.41	0.38	0.41	0.40	0.37	0.30	0.32	0.36	0.35	0.36	0.37
2A	0.51	0.50	0.50	0.46	0.47	0.44	0.47	0.46	0.43	0.34	0.37	0.41	0.40	0.41	0.43
2B	0.57	0.57	0.57	0.52	0.53	0.51	0.53	0.53	0.49	0.39	0.44	0.48	0.46	0.47	0.49
3A	0.53	0.52	0.52	0.48	0.48	0.46	0.48	0.48	0.44	0.35	0.39	0.43	0.41	0.42	0.44
3B	0.60	0.59	0.59	0.54	0.55	0.52	0.53	0.53	0.49	0.39	0.44	0.49	0.47	0.48	0.50
4A	0.53	0.52	0.52	0.49	0.49	0.46	0.49	0.48	0.44	0.36	0.39	0.43	0.42	0.43	0.44
4B	0.61	0.61	0.61	0.56	0.57	0.53	0.57	0.56	0.52	0.40	0.44	0.50	0.48	0.49	0.52
5A	0.53	0.52	0.52	0.49	0.49	0.46	0.49	0.48	0.44	0.36	0.39	0.43	0.42	0.43	0.44
5B **	0.61	0.61	0.61	0.56	0.57	0.53	0.57	0.56	0.52	0.40	0.44	0.50	0.48	0.49	0.52
6A	0.55	0.54	0.54	0.50	0.50	0.48	0.50	0.50	0.46	0.37	0.41	0.45	0.43	0.44	0.46
6B	0.63	0.63	0.62	0.57	0.58	0.55	0.58	0.58	0.53	0.40	0.45	0.52	0.48	0.51	0.53

[1] Cross-Delta flows are the sum of flows in Delta Cross Channel and Georgiana Slough. Low ratios in May of Above Normal and Wet Years reflect closure of Delta Cross Channel according to Decision 1485 constraints to minimize cross-Delta movement of salmon and diversion of young striped bass into the central Delta.

**Preferred Alternative

with the six project alternatives are usually similar to those with the No-action alternative. However, outflows were 5 to 10 percent lower with the project alternatives in July of representative critical and dry years. In these months, the mixing zone would be slightly farther upstream with a North Delta project than it would be without the project, which could slightly worsen conditions for the juvenile bass.

Table 5-24 shows that compared to No-action alternative, the North Delta alternatives would divert a higher proportion of water and presumably more juvenile striped bass from the Sacramento River into the interior Delta. The diversion of a higher proportion of juveniles into the interior Delta could adversely affect the overall production of bass, if the interior Delta provides poorer conditions than the Sacramento River for young striped bass as the Department of Fish and Game believes. Table 5-25 summarizes the impact of the project alternatives on striped bass.

General Impacts on American Shad

American shad were first introduced into the Sacramento-San Joaquin River System in 1871, when the system was still largely in its native state. The initial plant of about 10,000 young-of-the-year was followed by additional plantings, totaling 819,000 young fish from 1873 to 1881 (Skinner 1962).

The American shad population increased rapidly and soon supported a major commercial gill net fishery in the estuary during the spawning runs. American shad were sold in San Francisco markets by 1879. Catches regularly exceeded 1 million pounds from 1900 to 1945; about 5.6 million pounds were taken in 1917. After 1945 the fishery diminished, and in 1957 it was terminated by legislation due to public concern about the impact of the gill nets on striped bass (Skinner 1962).

Although American shad were commercially important, enthusiasm for sport fishing did not begin until the 1950s, when anglers began fishing the spawning grounds in the

Table 5-25
Impacts of Project Alternatives on Striped Bass
(Compared to Impacts of the No-action Alternative)

Alternatives	Entrainment Losses	Reverse Flow	Water Quality for Spawning[1]	Delta Outflow	SWP Exports	Delta Cross Channel Flow
2,A, 3A, 4A, 5A	2% reduction in losses June-August	Less frequent 20% Aug-Nov 30% May-July below-normal	7% improvement in April-May; 22% in representative year.	< 1% reduction April-July; 9% reduction in July of dry years.	1% increase May-July; 16% increase in June of critical years.	14% increase in proportion of Sacramento Riv. flow diverted.
3B, 4B, 5B, 6B	7% reduction in losses June-August	Less frequent 40% Aug-Nov 85% May-Jul	16% improvement in April-May; 38% in representative dry year	< 1% reduction Apr-Jul; 8% reduction yin July of dry years.	2% increase May-July; 24% increase in June of critical years.	33% increase in proportion of Sacramento Riv. flow diverted..
2B, 6A	7% reduction in losses June-August	Less frequent 40% Aug-Nov 55% May-Jul	18% improvement in April-May; 43% in representative dry year.	< 1% reduction Apr-Jul; 8% reduction in July of dry	2% increase May-July; 23% increase in June of critical years.	30% increase in proportion of Sacramento Riv. flow diverted.

[1]Salinity in San Joaquin River at Antioch.

upper Sacramento and San Joaquin River systems, particularly the main stem Sacramento, and the American, Feather, and Yuba rivers. Once established, the popularity of shad fishing grew, and by the mid-1960s, an estimated 100,000 angler days were being expended annually (California Fish and Game 1965). However, more recent surveys in 1977 and 1978 indicate that about 35,000 and 55,000 angler days were expended to catch 79,000 and 140,000 shad, respectively (Meinz 1981). The present bag limit is 25 fish per day, but most anglers typically release all, or most of, their catch. The American shad spawning run was estimated to be 3.04 million in 1976 and 2.79 million in 1977 (Stevens et al. 1987).

Additional sport fishing occurs in the "bump net" fishery in the Delta at night. A long-handled chicken-wire dip net is fished in the prop-wash of a slow-moving boat; when a shad bumps the net, the "bumper" quickly tries to flip it on board. Essentially all fish caught are males, which apparently are attracted to the prop-wash as they would be attracted to a spawning female (DFG 1987).

Life History. American shad are anadromous, living primarily in the Bay and ocean as adults but using fresh water for spawning and nursery grounds. Historically, shad spawned throughout Delta fresh waters and upstream into both the Sacramento and San Joaquin rivers, but spawning has declined in the San Joaquin system, leaving the north Delta and Sacramento system upstream from Hood as the primary spawning areas.

Adults returning from the ocean begin passing through the Delta in late March or April (Stevens 1966). In fyke traps set in the Sacramento River at Clarksburg, American shad catches increase substantially through April and peak during May (Stevens et al. 1957). River temperatures during May generally range from about 57° to 75° F.

River flow may affect the distribution of American shad on their initial spawning runs in the Sacramento River system. The percentage of the runs formed by virgins in the American, Yuba, and mainstream Sacramento rivers tends to increase with the contribution of a stream to the flow immediately downstream from its confluence with adjacent river branches (Wixom 1981). The Feather River may not exhibit this tendency to the same extent because of a longer residence period for young fish in the Feather River, allowing them to become imprinted for homing on their maiden returns.

The shad fishery is affected by the distribution of adult fish. Hence, low spring flows in the tributaries most accessible to the American, Feather, and Yuba rivers not only reduce their shad runs, but also angling opportunities. Most repeat spawners in the Sacramento River system probably home to the tributary where they have spawned previously. Sampling of American shad eggs with nets set in the Feather River indicates that spawning occurs predominantly from May to July at temperatures of 63° to 75° F. (Painter et al. 1977).

The flow in most of the spawning areas washes the demersal but free-drifting eggs a short distance downstream before they are hatched. The main summer nursery of American shad appears to extend from Colusa on the Sacramento River to the north Delta, including the lower Feather River; some numbers of fish also use the south Delta.

In wet years, young shad are less likely to use the Sacramento River and more likely to use the north Delta than in dry years. This difference probably reflects the transport of eggs and young fish by river flow and indicates that annual flow differences cause the location of major concentrations of fish to vary (DFG 1987).

Although the food habits of juvenile American shad in California have not been studied extensively, Ganslee (1966) reported that *Neomysis*, copepods, larval fish and *Corophium* sp. were the primary food items found in the stomachs of a small sample of juvenile shad captured in the west Delta.

The food habits of juvenile American shad rearing in the upper Sacramento River and tributaries are not known, but studies conducted in East Coast rivers found young shad eating a wide variety of insects and zooplankton (copepods and cladocerans) with the diet of a particular population dependant on the prey items available (Walburg 1957, Massman 1963).

It is likely that shad in California have a similar flexible feeding strategy. During the time they are rearing in zooplankton-poor areas upstream of the Delta, shad probably depend primarily on insects originating in the wooded area surrounding the Sacramento River and its tributaries (Turner 1966). Shad rearing in or moving through the more open water areas of the Delta and west Delta would feed on zooplankton originating in the Delta waters.

Both sources of juvenile American shad food are threatened by human development. Continued removal of riparian and streamside vegetation in the Sacramento River system upstream from the Delta potentially reduces the amount of insect drop supporting young shad in those regions. Water development has reduced the abundance of zooplankton in the Delta, primarily because the use of Delta channels as conduits to carry water south to the CVP and SWP pumps has increased flow velocities, reduced water residence times, and brings large volumes of zooplankton-deficient Sacramento River water into the central and south Delta (Turner 166, Turner and Heubach 1966, Heubach, 1969, Knutson and Orsi 1983, Orsi and Mecum 1986).

Abundance of young American shad in the Sacramento-San Joaquin Estuary varies annually by more than an order of magnitude, and the strongest year classes occur in the years with the highest river flows during the spawning and nursery period (Stevens and Miller 1985). Flows during April—June appear to be most important in explaining year-to-year variation in abundance.

The status of the American shad run in the Feather River and its associated recreational fishery was not well documented prior to construction of the Oroville Project, but anecdotal evidence on angler use and catches suggests that the run was substantial (Painter and Taylor 1977). Generally reduced spring flows and increased spring temperatures since construction of the Oroville Project may have reduced the run.

Young American shad are vulnerable to diversion by the State and federal pumping plants in the south Delta. Juvenile shad spawned in the south Delta and Mokelumne River channels would be drawn to the pumps as larvae and newly metamorphosed small fish, whereas Sacramento system juveniles tend to be drawn through the Delta Cross Channel and across the Delta during their downstream migration. From 1968 through 1985, American shad have been the third most common fish at the SWP fish facilities, with annual recoveries as high as 3 million. In 1967, CVP recoveries exceeded 8 million (DFG 1987).

Evaluations of screening efficiency comparable to studies for striped bass and salmon have not been made for American shad, but larger fish in the fall are probably screened fairly efficiently. Conversely, based on results for other species, screening efficiencies for newly metamorphosed juveniles in late spring and early summer are probably quite low. Without estimates of screening efficiency rates, total entrainment losses cannot be accurately estimated.

American shad are intolerant of handling. Tests have shown that losses of American shad successfully screened at the SWP fish facility exceeded 50 percent during summer months with slightly lower mortalities during the cooler fall months. These high-handling mortalities suggest that the only practical strategy for reducing losses may be pumping schedules that minimize shad entrainment (DFG 1987).

Impacts of NDP. In the discussion above seven factors were identified which are thought to be important to the estuary's American shad population. The seven factors are:

1) April through June flow conditions as they affect adult spawning distribution and, consequently, the availability of the fish to anglers;

2) spring flow conditions as they affect juvenile abundance;

3) spring flow conditions as they affect juvenile distribution;

4) spring and summer cross Delta flow ratios as they affect exposure to entrainment and rearing habitat;

5) SWP/CVP export levels as they affect entrainment losses of young American shad and their food supply;

6) riparian habitat conditions affecting juvenile shad food supply; and

7) flow conditions in Delta water transport channels as they affect juvenile shad food supply.

No-action Alternative. The annual fall abundance of juvenile American shad is positively correlated with April-June levels of Delta inflow (Stevens and Miller 1983). Inflow from the Sacramento River is a major component of Delta inflow and outflow to Suisun Bay, is composed of flows from the upper Sacramento River and its tributaries, and is an indicator of a variety of flow conditions. Since shad use the rivers, Delta, and eastern Suisun Bay for spawning and/or rearing, the observed positive correlation between inflow and juvenile shad production could result from flow effects in any or all of the areas mentioned.

The No-action alternative will generally increase April-June Feather River flows which in turn will increase Sacramento River flow below its confluence with the Feather River. These changes in river flows will not generally result in greater Delta outflows, because exports will increase. Increased river flows are likely to transport more larval and juvenile shad into the Delta where food densities are generally greater, which could be beneficial. On the other hand fish transported into the Delta are more likely to be entrained in the CVP/SWP export facilities.

During spring and summer, larval and juvenile American shad are migrating or being transported from upstream spawning areas to the Delta. During this downstream movement they are vulnerable to diversion into the central Delta via the Delta Cross-Channel and Georgiana Slough. Fish that are diverted are more likely to be entrained in the CVP and SWP export facilities and less likely to reach the productive entrapment zone. However, the no-action alternative will not significantly change the proportion of Sacramento River diverted into the central Delta.

No-action alternative export rates will be generally higher than in the recent past, which will cause increases in entrainment losses.

It is not possible to predict how the abundance and quality of riparian vegetation in American shad nursery areas will change under the No-action alternative. In general, during recent decades flood control activities have reduced riparian vegetation in the lower rivers and Delta. To the extent that degradation of riparian vegetation continues in the future, a reduction in insect drop will likely occur. A reduction in this food supply for juvenile shad would have its greatest effect in the river nursery areas where zooplankton densities are low compared to densities in the Delta.

Under the no-action alternative, Delta channel capacities or cross-Delta flow ratios, and thus northern Delta channel velocities or water residence times, are not expected to change significantly. Therefore, the capability of those areas to produce food for young shad are not expected to change.

The increased exports expected under the no-action alternative will be accompanied by increased water velocities and reduced residence times in some southern Delta channels. These changes would be expected to reduce productivity in affected channels.

Preferred Alternative. Anticipated mean monthly April-June Feather River flows are greater under the preferred alternative than under the no-action alternative in critical water years, and April flows are greater in all but wet years (Table 5-14). During other combinations of months and water year types there is essentially no difference in April, May, or June flows between the two alternatives. Assuming that there will be no offsetting changes in flow in the Sacramento or Yuba rivers, the greater spring Feather River flows under the preferred alternative should cause a greater number of spawners to enter the Feather River, where they are more available to anglers. Increased Feather River flows result in greater Delta inflows, which may increase juvenile shad production in the Feather River and downstream.

The preferred alternative increases the proportion of Sacramento River inflow diverted into the Delta Cross-Channel and Georgiana Slough during spring and early summer (Table 5-24). These increases are greatest when inflows are low and the Delta Cross-Channel is open. As this cross Delta flow ratio increases, a greater percentage of downstream migrant shad will probably be diverted into the Central Delta. Although the data are not available to quantify this impact it may increase shad losses due to entrainment at the SWP and CVP. Diverted fish will also have a longer, more circuitous migration route to the Bay and ocean.

Anticipated SWP export rates under the preferred alternative are generally greater than those under the No-action alternative and the timing of exports differs between the two alternatives. The effect of these and other changes on American shad entrainment losses is discussed later in this chapter.

The preferred alternative will achieve its flood control and cross Delta flow objectives partially through the modification of channels in the northern Delta. Where those modifications involve the use of levee setbacks, the opportunity exists for improvements in both the quantity and quality of riparian and emergent vegetation, which provides important insect drop and cover for juvenile American shad. Areas that are dredged are likely to lose shallow areas and berms that support emergent and riparian vegetation, thus adversely affecting juvenile American shad production.

The increase in cross-Delta flows and exports resulting from the NDP will not significantly decrease residence times or water velocities in major Delta transport channels because channel capacities will be enlarged. Therefore, reductions in productivity are not expected in those channels.

Other Alternatives. The various NDP alternatives are similar to the preferred alternative with respect to their effects on Feather River flows and SWP export levels. The alternatives do differ substantially in the extent to which they increase cross-Delta flows (Table 5-12). Diversion of American shad through the Delta Cross-Channel is a negative, but unquantifiable, impact, which increases as the diversion rate increases.

The alternatives also differ in the degree to which levee setbacks and dredging are used to achieve channel capacity objectives. In general, those alternatives that use a greater proportion of levee setbacks provide greater potential for improving insect-drop-producing vegetation.

General Impacts on Sturgeon

Two sturgeon species, white sturgeon (*Acipenser transmontanus*) and green sturgeon (*Acipenser medirostris*), inhabit the estuary. Both are native, anadromous species. At this time a reasonable assessment of project impacts can only be made for white sturgeon, because very little is known about the biology of green sturgeon in the estuary. The white sturgeon population is presently supported entirely by natural reproduction.

The white sturgeon population in the estuary supports an increasingly popular sport fishery, in great part due to the large size individual fish attain. The current California sportfishing record for this species is a fish caught in Carquinez Strait in the mid-1980s that weighed over 450 pounds. The number of legal size (> 40 inch) white sturgeon in the estuary has been estimated 8 times since 1954. These estimates have fluctuated from 11,200 in 1954 to 128,300 fish in 1984 (Figure 5-20). The annual sport fishing take in the estuary in recent years has averaged about 10,000, roughly 10 percent of the legal size stock (Figure 5-20) [Kohlhorst et al. 1990].

White sturgeon generally complete their life cycle within the estuary and its major tributaries, although a few fish enter the ocean and make extensive coastal migrations. During most of the year, adult white sturgeon are concentrated in San Francisco, San Pablo, and Suisun bays, feeding principally on bottom-dwelling invertebrates, such as clams, crabs, and shrimp. Mature sturgeon ascend the Sacramento River, the Feather River, and possibly the San Joaquin River to spawn, primarily during March and April. Spawning in the Sacramento River occurs primarily above the town of Knights Landing, historically extending upstream above the present location of Shasta Dam. Presently, most spawning occurs between Ord Bend and Knights Landing, although some fish migrate above the Red Bluff Diversion Dam to spawn when the dam gates are open (Kohlhorst 1976).

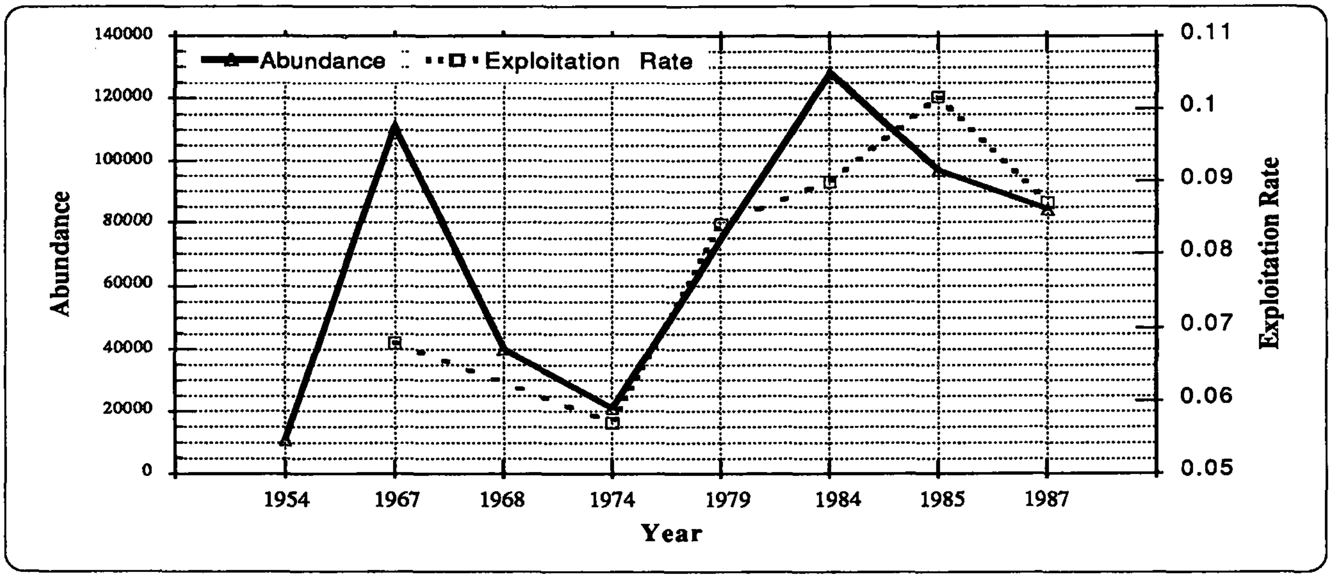


Figure 5-20. Abundance Levels and Annual Sport Fishing Take for White Sturgeon, 1954 – 1987

White sturgeon make spring migrations into the San Joaquin River between Mossdale and the mouth of the Merced River. While these migrations could be for the purpose of spawning, no collections of eggs or larvae have been made to confirm this (Stevens and Miller 1970).

White sturgeon spawn over rock and gravel, to which the fertilized eggs adhere. After hatching, there apparently is a general downstream movement of young fish into the upper estuary, but the details of this migration are not known at this time. It has been observed that in years of high river flow, larval sturgeon are more abundant in the upper estuary than in dry years, suggesting that river flow may play a role in the dispersal of young sturgeon from the spawning grounds. The upper estuary, Suisun Bay, and the Delta are apparently the principal nursery areas for sturgeon during their first year of life (Stevens and Miller 1970).

White sturgeon are particularly vulnerable to the effects of over-harvesting because they mature slowly. Female white sturgeon do not reach sexual maturity until they are at least 15 years old and about 4 to 5 feet long. Commercial fishing in the late 1800s and early 1900s led to a decline in the sturgeon stock, prompting a prohibition on all fishing from 1917 through 1954. In 1954, the Fish and Game Commission established a sport fishery, which continues to the present. For most of the period since 1954, there has been a creel limit of one fish per day and a 40-inch minimum size limit. In response to recent increases in the amount and efficiency of recreational angling for sturgeon, the Fish and Game Commission adopted more restrictive regulations in 1990, raising the minimum size limit to 42 inches and establishing a maximum size limit of 72 inches. The minimum size limit will likely be raised by 2 inches each year until it reaches 48 inches.

Observed fluctuations in the sturgeon population since 1954 appear to be due primarily to variations in recruitment (the production of young fish) rather than variations in the annual survival rates of older age classes (Kohlhorst 1990). Furthermore, it appears that the size of the spawning stock and survival during the first few months of the life cycle are the principal determinants of year class strength. Adult age distribution, catches of juvenile sturgeon at the SWP fish salvage facilities, and juvenile sturgeon occurrence in DFG's Bay study trawl samples all suggested that annual production of young sturgeon varies widely and that production is positively associated with flow conditions in the spring spawning and rearing period.

The tendency towards greater production of juvenile white sturgeon in years of greater outflow is suggested by two different measures of year class strength. One is based on the estimated number of juvenile sturgeon salvaged at the Skinner Fish Facilities per thousand AF of water exported during August, September, and October and outflows during each year from 1968 through 1987. The other is based on IESP Bay Study trawl catches from 1980 through 1986 (Figure 5-21). Both measures indicate the relative abundance of sturgeon.

Salvage rate has obvious theoretical weaknesses as a measure of juvenile sturgeon abundance, the most important being that sturgeon distribution may change from year to year whereas the location of the pumping plant does not. Whereas Bay Study sampling is probably a more accurate measure of abundance, because it covers a wide area of the estuary, data have been collected only since 1980. Nevertheless, the two sets of abundance are roughly consistent (Figure 5-22). The low salvage rate estimates in 1983 relative to Bay study catches probably indicate a tendency for salvage rate to under-estimate abundance in extremely wet years, perhaps because the young sturgeon are distributed lower in the estuary by high flows. The low abundance indices shown in Figure 5-23 for 1969 and 1986 may be evidence of this effect.

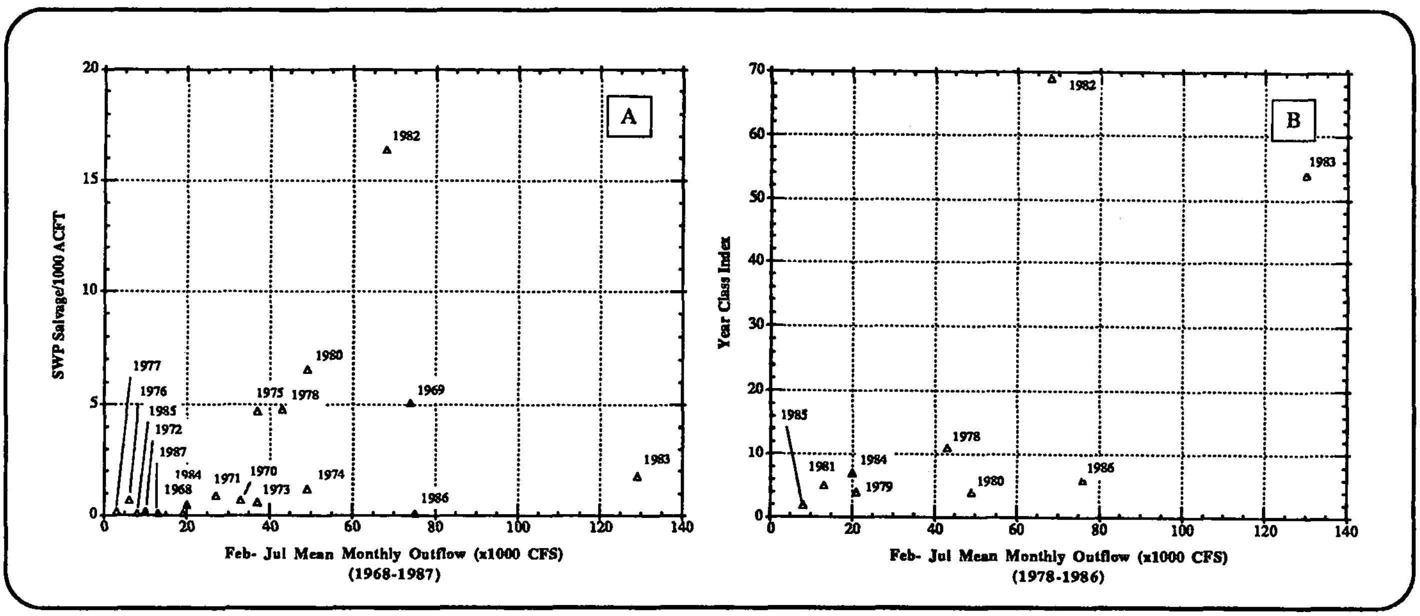
The February through July outflows used in Figure 5-22 encompass the spawning, out-migration, and early juvenile rearing period. The the strength of the association between the two measures of abundance and outflow varies for the individual months in that period (Table 5-26).

For the salvage estimates, correlation coefficients were calculated for all years from 1968 through 1987, with 1969 and 1983 excluded. The data were examined with 1969 and 1983 excluded because of the possibility that salvage rates may have under-indicated abundance in those extremely wet years. For both measures of year class strength there is a very weak positive association between outflow in February and March and abundance. Conversely, April and May outflows are closely associated with all measures of abundance. June and July outflows appear to be less closely associated with abundance than are outflows in April and May.

Based on the correlation coefficients presented in Table 5-26, April and May outflow appear to be most closely associated with juvenile sturgeon production. When salvage is plotted against April through May flows, during the 20-year period 1968 through 1987 (Figure 5-23), the data suggest a threshold of about 20,000 cfs, below which, sturgeon seemed to have produced relatively poor year classes.

The mechanism responsible for the positive association between sturgeon year class strength and outflows is not well understood. The April through May period encompasses the latter part of the spawning season through the

Figure 5-21. Relationship Between Mean Monthly February Through July Delta Outflow and Two Measures of White Sturgeon Year Class Strength. Plot A uses August Through October Salvage at the J. E. Skinner Fish Facility per 1,000 AF Exported by the SWP. Plot B uses the Catch of Each Year Class in the First 3 Years of Life in the Bay Study Trawl.



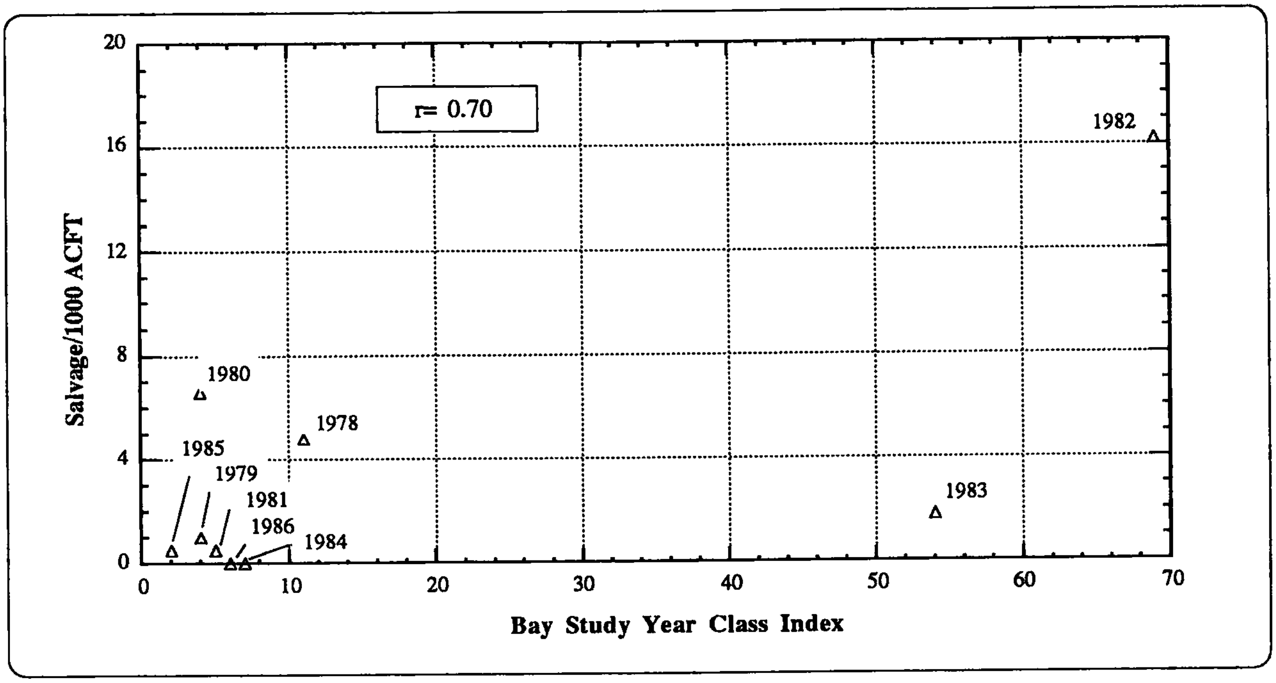


Figure 5-22. Relationship Between Two Measures of White Sturgeon Year Class Strength

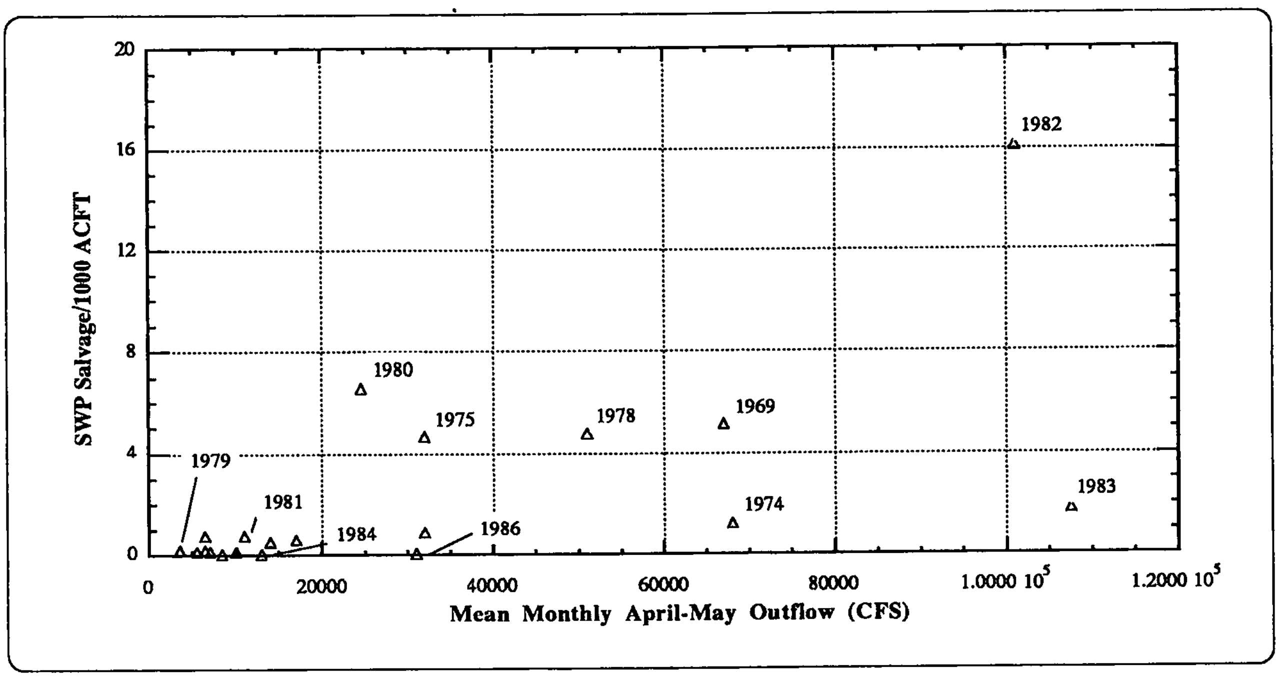


Figure 5-23. Relationship Between April-May Delta Outflow and White Sturgeon Year Class Strength

Table 5-26
Correlation Coefficients Between Delta Outflow and Two Measures of Sturgeon Year Class Strength[1]

Outflow Month	1968–1987 SWP Salvage	1980–1986 Bay Study Catches
February	0.250 (0.239)	0.336
March	0.190 (0.306)	0.504
April	0.656^{X} (0.744^{X})	0.955^{X}
May	0.525^{Y} (0.860^{X})	0.848^{X}
June	0.372 (0.750^{X})	0.768^{Y}
July	0.284 (0.724^{X})	0.724^{Y}

$^{X}P < 0.05$
$^{Y}P < 0.01$

[1]Correlation coefficients in parentheses are with 1969 and 1983 excluded.

early larval and juvenile stages. River flow could be important during this period, since spawning, hatching, and early rearing take place in the upper river, but the high degree of correlation between Sacramento River flow and outflow makes it difficult to separate the effects of the two factors.

At this time, very little is known about the habits and needs of white sturgeon in their early weeks of life. It has been observed that larval sturgeon are more abundant in the Delta during high flow years, suggesting that high flows transport them there. and that they survive better as a result. If survival in the estuary is greater than in upstream areas, it could explain the associations between spring flow and fall abundance. Using Dingall/Johnson funds, DFG has recently initiated studies to develop better estimates of year class strength and to better document the spawning and early life history of white sturgeon.

No–action Alternative. Very little is known about the biology of white sturgeon in the Estuary during the first few weeks of life to explain with certainty the apparent positive association between year class strength and April–May outflow. However, given that flow 1) greatly influences conditions in and access to the spawning grounds, 2) affects the dispersal of young from the spawning grounds, and 3) affects the size, location, and quality of the nursery area in the upper estuary, a relationship between outflow and year class strength is likely.

Figure 5–24 shows the no–action and preferred alternative April and May outflow for the 1956 through 1978 hydrology. The period 1956 through 1978 was chosen to examine changing habitat conditions for juvenile white sturgeon because it is the period of overlap between the available actual data and the modelled hydrological results.

Water development through 1978, in general, has greatly reduced April and May flows. As discussed previously, when outflows are lower than about 20,000 cfs in April through May, sturgeon have not produced strong year classes in the recent past. . Actual conditions reduced the number of years with flows above the apparent threshold. This leads to the conclusion that juvenile sturgeon production may be depressed by existing levels of water development.

Preferred Alternatives. The preferred alternative does not substantially affect either the magnitude of April and May Delta outflow or the number of years above the apparent threshold values in comparison with the no–action alternative (Figures 5–24 and 5–25). Within the constraints of our current understanding of factors influencing white sturgeon production, this suggests that the effects of the preferred alternative will be similar to those of the no–action alternative.

Other Alternatives. All of the proposed project alternatives affect outflows very similarly. Therefore, the other alternatives would be expected to affect white sturgeon similarly to the preferred alternative.

General Impacts on Resident Fishes

Resident fishes as defined here, are non–migratory (non–anadromous) species which complete their life cycle in the Delta and the lower reaches of its tributary rivers. The Delta itself is not a totally fresh water system, year round. Therefore species that might be termed brackish water species, such as tule perch, are included here. These species are usually found in fresh water, but can withstand periods of higher salinity.

Native Fishes. Central California is dominated by the large and diverse Sacramento–San Joaquin River drainage system. Because it is isolated from other systems, by coastal mountain ranges, the Cascades, and the Sierra Nevada, a unique fresh water fish community evolved. Seventeen species of fresh water fish are endemic to the system and live nowhere else (Moyle 1976). Eleven of these are resident species in the Delta.

The resident native species of the Delta evolved to live in the stagnant backwaters, shallow tule beds, deep pools,

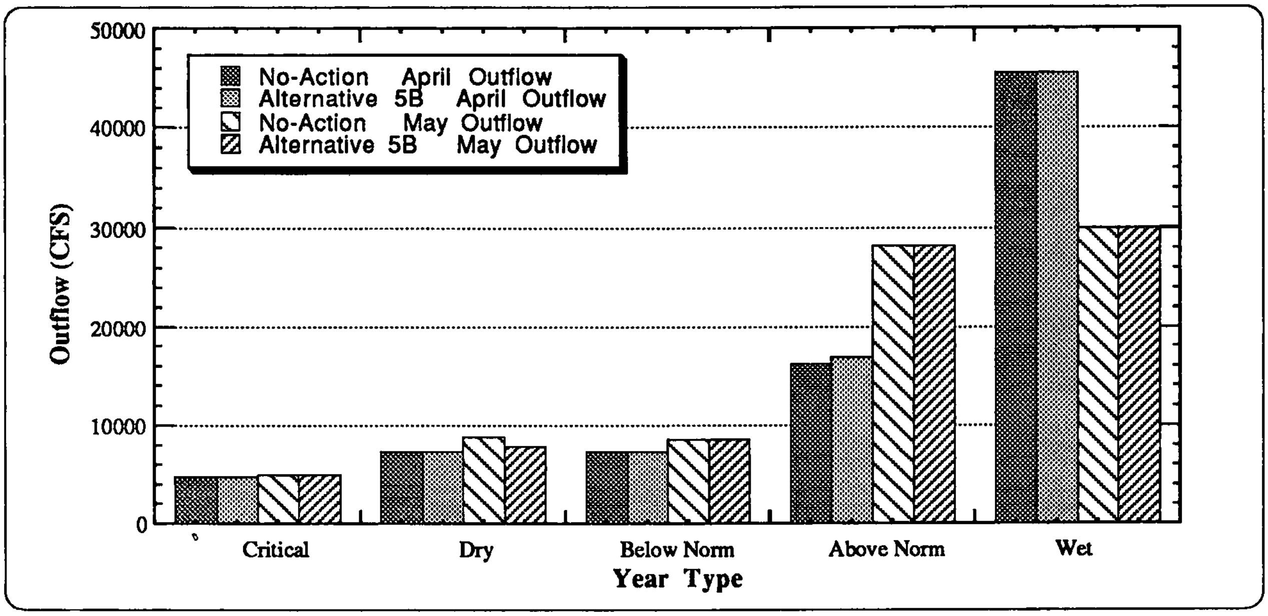


Figure 5-24. Comparison of April-May Delta Outflow for the No-Action and Preferred Alternatives

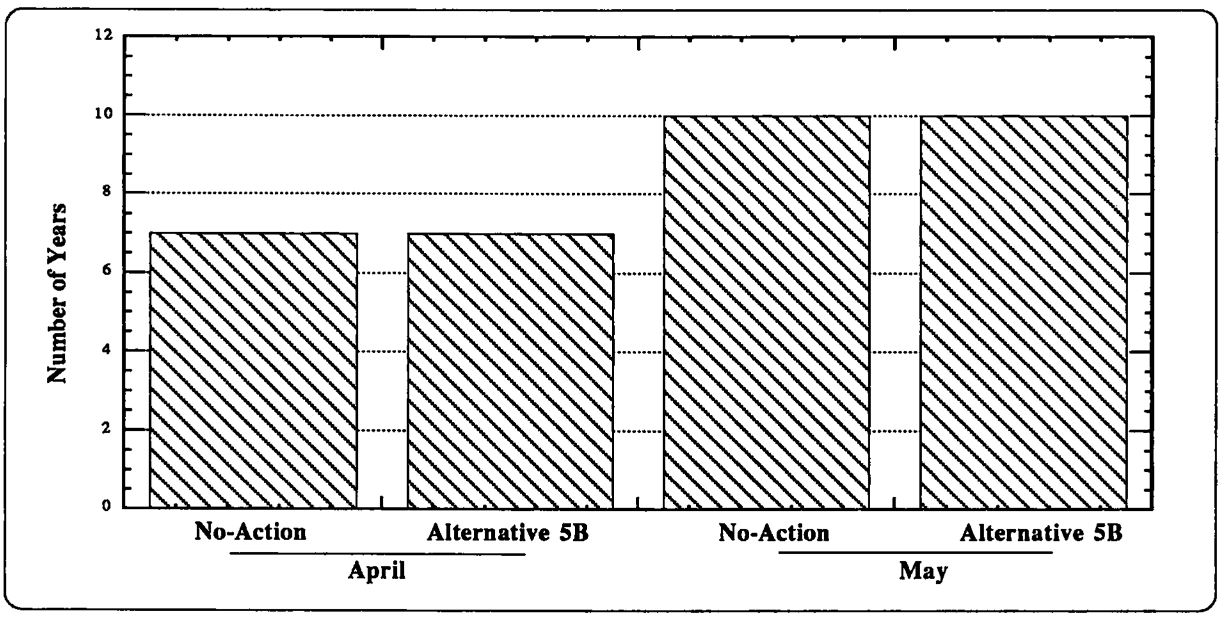


Figure 5-25. Comparison of the Number of Years During the 1956-1978 Period When April-May Delta Outflow Exceeded 20,000 cfs

and long stretches of slow-moving river waters of the Delta of the past (Moyle 1976). Land reclamation, introduction of exotic species, and water project operations have changed conditions in the Delta. Many native fishes have either become extinct, such as the thicktail chub, or survive in greatly reduced numbers, such as the Sacramento perch.

Five native resident species that are found in the Delta are members of the family: Cyprinidae, commonly known as minnows (Table 5-27). Two of these minnows, the Sacramento squawfish and hardhead, along with the Sacramento sucker, were historically abundant in the Delta (Moyle 1976). Presently Sacramento squawfish and hardhead are now found in low numbers. It is presently believed this reduction is due mostly to habitat changes, but competition from introduced species has contributed (Moyle 1976).

Minnows are usually thought of as small fish, less then 10 cm; however, many native minnow species in western North America are large. Hitch, Sacramento blackfish, and Sacramento splittail commonly reach 20-35 cm, 35-45 cm, and 30-40 cm in length, respectively. All native minnows were once heavily fished for food by native Americans (Moyle 1976). Formerly there was a small commercial fishery for Sacramento splittail and Sacramento blackfish, and the Sacramento blackfish is still harvested commercially from Clear Lake. Both species have potential for aquaculture. There are presently recreational fisheries for tule perch, squawfish, Sacramento splittail, and Sacramento sucker in the Delta and the lower American and Sacramento rivers.

The Sacramento splittail is a native minnow that lives mostly in the slow-moving stretches of the Sacramento River up to Red Bluff Diversion Dam, the Delta, and in the Napa and Suisun marshes (Moyle 1976; DFG unpublished data). After high flows they have been found in Suisun Bay, San Pablo Bay, and Carquinez Straits (Moyle 1976). Turner (1966) reported finding them evenly distributed in the Delta, while a later study found them most abundant in the north and west Delta on flooded island areas in association with other native species (DFG 1987).

Sacramento splittail are tolerant of brackish water, being caught at salinities as high as 10-12 parts per thousand (ppt) (Moyle 1976). During spring, they congregate in dead-end sloughs of the marsh areas of the Delta, and Napa and Suisun marshes, to spawn over beds of aquatic or flooded terrestrial vegetation (Moyle 1976; DFG unpublished data). They have been observed to migrate up the Sacramento River and spawn on the grass at Miller Park (DFG pers. comm.)

The Sacramento-San Joaquin River Delta has two native, resident species of smelt: the longfin smelt and the Delta smelt. The longfin smelt is found in the more saline areas of the estuary and is discussed in the San Francisco Bay Impacts section. The Delta smelt is found in the more fresh water areas. A recent and continued dramatic decline in its abundance led to the recommendation that it be listed as a threaten species (Stevens et al. 1990). The Fish and Game Commission rejected this recommendation pending more information of the species status.

The Delta smelt is found only in the Sacramento-San Joaquin River Estuary. Most of the year the population is found in the San Joaquin River below Mossdale, in the Sacramento River below Isleton, and in the Suisun Bay and marsh region. They are also found in Carquinez Strait and San Pablo Bay when high river flows move the salinity gradient downstream. Delta smelt have been found at salinities as great as 10 ppt, but most of the population occurs at less then 2 ppt. They school in open surface waters (Moyle 1976).

Delta smelt appear to be opportunistic feeders on planktonic copepods, mostly the native *Eurytemora affinis*, and on the introduced *Pseudodiaptomus forbesi* in years when it occurs in high abundance (Stevens et al. 1990). Also included in the diet are cladocerans, amphipods, and insect larvae. When the population moves downstream to Suisun Bay, the opossum shrimp, *Neomysis*, becomes an important food item (Moyle 1976).

The majority of spawning occurs in the dead-end sloughs, the shallow edge-waters of Delta channels, and in the Sacramento River from February through June. Spawning occurs in fresh water at temperatures of 7-15^0 C. Females produce 1400-2900 demersal, adhesive eggs on rock, gravel, tree roots, and submerged vegetation. After hatching, larvae drift downstream to the mixing, or entrapment zone. Growth is rapid, with juveniles reaching 40-50 mm long by August. Adult lengths, 55-77 mm, are reached when fish are six to nine months old (Stevens et al. 1990).

Delta smelt larvae and pre-spawning adults generally occupy the brackish water areas downstream of the Delta, particularly in Suisun Bay. The summer-fall geographical distribution is strongly influenced by Delta outflow. As outflow increases, more of the population occurs in

Table 5–27
Resident Fish Species of the Sacramento–San Joaquin Delta

Centrarchidae	Cyprinidae
Largemouth Bass	Hitch*
Smallmouth Bass	Sacramento Blackfish*
Spotted Bass	Sacramento Splittail*
Bluegill	Sacramento Squawfish*
Redear Sunfish	Golden Shiner
Green Sunfish	Goldfish
Warmouth	Carp
Black Crappie	Hardhead*
White Crappie	Fathead Minnow
Pumpkinseed	
Sunfish Hybrids	**Others**
Sacramento Perch*	
	Sacramento Sucker*
Ictaluridae	Tule Perch*
	Bigscale Logperch
White Catfish	Inland Silversides
Channel Catfish	Mosquitofish
Brown Bullhead	Threespine Stickleback*
Black Bullhead	Prickly Sculpin*
	Delta Smelt*
	Threadfin Shad
***Indicates native species.**	Yellowfin Goby

Suisun and San Pablo bays; in low flows the population is confined to the channels of the Delta.

As spawning approaches in the late winter and spring, Delta smelt adults migrate to fresh water. Most spawning occurs in the upper Delta, including dead end sloughs and shallow water, in Montezuma Slough near Suisun Bay, and in the Sacramento River upstream of Rio Vista (Radtke 1966, Wang 1986). Delta smelt are a short-lived species; most die after spawning at one year of age, but some survive to two years.

Until very recently, Delta smelt were abundant in the Delta. During the 1980's, however, the population decreased substantially. Delta smelt populations have declined in the past, but have generally recovered within a few years. The population reductions began in the south and east Delta during the 1970's, prior to the overall population decline of the 1980s. (Stevens et al. 1990).

Data indicate that abundance of a Delta smelt year class largely depends on environmental conditions affecting survival of eggs and young fish, rather than the abundance of adult spawners. However, to investigate the cause of the population decline, DFG evaluated the following factors: Delta outflows, food supply, reverse flows, water temperatures, and water transparency. The analysis was unable to point to any one environmental factor as controlling Delta smelt population abundance (Stevens et al. 1990).

Many native resident fish species are most abundant in the north and west Delta (DFG 1987). These species often have life histories that are similar to that of the Delta smelt. They spawn in dead-end sloughs, eggs are adhesive and demersal, and the larvae are planktonic. Impacts of the NDP on these species would be similar to its effect on Delta smelt.

The tule perch is the only fresh water species of the surf perch family, Embiotocidae. Tule perch are euryhaline and have been caught in salinities of up to 18 ppt (DFG unpublished data). The surf perches are livebearers; the tule perch gives birth to about 20–80 young in May or June

(Moyle 1976). They can live in a various habitats, varying from sluggish, turbid channels in the Delta to clear, swift-flowing sections of river. They are able to live in fast water by taking advantage of eddies that occur behind submerged boulders and logs. They prefer beds of emergent aquatic plants or overhanging banks (Moyle 1976). Tule perch eat small invertebrates that are found on the substrate or in midwater (zooplankton); tule perch consume mostly amphipods, midge larvae (Chironomidae), and small clams and crabs (Moyle 1976).

Tule perch are native to low-elevation waters of the Sacramento-San Joaquin River system, as well as to Clear Lake, Coyote Creek, and the Russian, Napa, Pajaro, and Salinas rivers (Moyle 1976). DFG (unpublished data) found them to be the fifth most abundant species in the Napa River during the 1974–79 period. Tule perch appear to be extinct in the Pajaro, Salinas, and San Joaquin rivers, and are absent from many localities where they were previously collected in the early 1900's (Moyle 1976).

Moyle (1976) feels that this indicates a reduction in population abundance due to habitat changes in the Delta, including reduced flows, increased turbidity, heavy pollution, and reduced emergent and overhanging cover, which have reduced or impaired the quality of habitat. Recently, populations have become established in O'Neill Forebay of San Luis Reservoir, presumably due to water exports.

Introduced Fishes. Three families of fishes dominate the Delta's introduced resident fish assemblage: Centrarchidae, Cyprinidae, and Ictaluridae. The centrarchid family is represented by the introduced black basses and various sunfishes (Table 5-27).

Largemouth bass are the most abundant of the black basses in the Delta and are a popular sport fish. Largemouth bass are solitary carnivores whose adult diet consists mainly of fish and crayfish, along with a secondary amount of insects and larger species of zooplankton (Turner 1966; Moyle 1976). Largemouth bass spawn in spring when water temperatures rise above 14–16^0 C and continue to spawn through June at water temperatures up to 24^0 C (Moyle 1976). Nests are shallow depressions in sand and gravel at depths of one to two meters, near submerged objects in non-colonial aggregations (Moyle 1976).

The various sunfish species are also opportunistic carnivores, feeding on insects, aquatic crustaceans, snails, and clams (DFG 1978). Turner (1966) found *Corophium* and *Neomysis* important food items of warmouth and black crappie; *Corophium*, tendipedid larvae and pupae, and the isopod *Exosphaeroma* were important to bluegill. Moyle (1976) indicated *Corophium* and *Neomysis* are important to white and black crappie. Fish are also a component of their diet but to a lesser extent than for largemouth bass (Turner 1966; Moyle 1976). They all spawn in shallow water during spring and summer when water temperatures reach 57 to 75^0 F. Their spawning behavior is roughly similar to that of largemouth bass; they build nests near submerged objects or aquatic vegetation (DFG 1987). Except for the warmouth, they tend to form nesting colonies. Their eggs are adhesive and sink, attaching to the substrate. After the young hatch, they are guarded by the male for a short period, after which they disperse to the shallows (Moyle 1976).

DFG studies have found that introduced species, the sunfishes in particular, are most abundant in the east Delta (DFG 1987). Turner (1966) caught the majority of black crappie, bluegill, and warmouth in the dead-end sloughs of the northeast Delta, including Hog, Sycamore, and Indian sloughs. Their abundance is correlated primarily with the dead-end slough channel type and secondarily with the intermediate salinities and water clarity characteristic of the east Delta (DFG 1987). They were also abundant in oxbows, channels behind berm islands, and small embayments. This implies a preference for calmer waters and riparian or aquatic vegetation characteristic of those areas (DFG 1987).

The introduced cyprinids are golden shiner, goldfish, and carp. Carp is by far the most common. Golden shiners live primarily in sloughs and are associated with dense mats of aquatic vegetation. They will tolerate low summer oxygen levels and water temperatures as high as 35^0 C. They are typically found with introduced sunfish. Golden shiners are a schooling fish, staying mostly in littoral areas. Lengths can reach 20 cm (Moyle 1976).

Golden shiners spawn from March through August. Exact timing is dependent on water temperatures, usually occurring at temperatures of 15–20^0 C. The adhesive eggs are deposited on submerged vegetation and bottom debris. The eggs hatch in four to five days, and the fry school in large numbers close to shore. Golden shiners are widely used as a bait fish (Moyle 1976).

Goldfish populations generally become established in warm, often oxygen poor water in areas with mild winters. They are best suited for sloughs containing heavy growths of aquatic vegetation where they feed mostly on algae.

Goldfish may reach lengths of 41 cm, and may live 25-30 years. Spawning, in their home range, occurs at temperatures of 15-32^0 C, with the first spawn of the year in April or May (Moyle 1976).

Carp are very similar to goldfish in their life history and preferred habitats. These two species have even been known to hybridize. Although what appears to be spawning behavior has been seen in the Delta, juveniles less then 100-150 mm are extremely rare (DFG pers. comm.). Carp are very widespread in the Delta and are common even in the major open channels (Don Stevens pers. comm.).

The third major group of introduced species is the ictalurid or catfish family. White catfish, the most abundant, are more than 35 times as abundant, on average, as any other catfish species in the Delta. White catfish are carnivorous bottom feeders, consuming aquatic crustaceans, mollusks, insects, and fish.

Amphipods and *Neomysis* are the most important food items for both juveniles and adults (Moyle 1976). White catfish spawn in June and July when water temperatures exceed 21^0 C (Turner 1966). The female uses her fins to fan out a shallow nest depression in the substrate, the breeding pair spawns, and the adhesive eggs settle and stick to each other, forming an egg mass. One or both parents guard the eggs and the newly hatched young for a few weeks until the young disperse in schools (DFG 1987).

White catfish were found to be the dominant resident species of the south Delta (DFG 1987). Their abundance in this area maybe due to their greater tolerance of brackish water with salinities up to 12 ppt (Moyle 1976). DFG (1987) and Turner (1966) found them to be somewhat less abundant in the central and east Delta, and least abundant, but still common, in the north and west Delta.

The white catfish population in the Delta has been estimated by a DFG tagging study at between 3 and 8 million (1978-1980, unpublished data). No information on abundance is available for white catfish prior to operation of the CVP and SWP; therefore, the effects of the projects on their abundance are difficult to determine. The current distribution of white catfish, however, approximates that found in the early 1960's before SWP exports began; therefore, changes in flow patterns induced by export operations and recent local diversions apparently have not to have affected white catfish distribution.

Channel catfish and brown and black bullheads have similar food preferences, with the exception that channel catfish probably consume more crayfish, clams, and fish than the other species (DFG 1987).

Channel catfish prefer the main channels of large streams (Moyle 1976). They were caught most often in areas of fast water in rivers and channels upstream from the central Delta, and were not taken in the west Delta (Turner 1966). Channel catfish nest in log jams or undercut banks; in ponds they will use old barrels or similar sites (Moyle 1976). Spawning occurs at temperatures of 21-29^0 C (Moyle 1976).

Brown and black bullheads were commonly found in the back of dead-end sloughs of the Delta and were not taken in the west Delta (Turner 1966). Brown bullheads are much more common and wide spread in California because they can adapt to a wider variety of habitats (Moyle 1976). Social and breeding behavior of both species are similar. Adults school and are most active at night (Moyle 1976). Nest building and rearing are similar to that described for white catfish.

Sunfishes, catfish, and bass—the principal resident gamefish of the Delta—support an important recreational fishery and are, respectively, the second, third, and fourth most commonly caught groups of gamefish in the State. White catfish are the resident gamefish most often caught in the Delta. Largemouth bass are a major gamefish throughout the State, and in recent years large bass fishing tournaments have been organized in the Delta; 33 major tournaments and numerous smaller ones were held during 1989 (DFG, unpublished data). The harvest rate for bass in the Delta (about 30 percent) is somewhat lower than in fresh water reservoirs (50 percent), but it is still substantial, indicating the existence of an important and thriving largemouth bass sport fishery.

Although they are not commonly sought by anglers, the nongamefish of the Delta still fulfill important roles. Some serve as forage for gamefish, while others compete with or prey on gamefish. Each of the resident non-gamefish has intrinsic ecological value, but in general, detailed knowledge of their life histories, population dynamics, and role in the community ecology of the Delta is limited.

Impact of NDP. DFG has recently completed a study of abundance, distribution, and habitat preferences of resident fish in the Delta (DFG 1987). The following findings of this study are relevant to an assessment of NDP impacts:

- Riprap banks are favorable habitat for only a few of the less desirable resident fish species in the Delta.
- Instream vegetation is favorable for largemouth bass, white catfish, and redear sunfish, three of the most important recreational resident fishes.
- Transport and non-transport channels differ in their species assemblages. Whereas catfish and black crappie were among those fish abundant in non-transport channels, largemouth bass and redear sunfish were more abundant in transport channels.
- Dead-end sloughs, oxbows, channels behind berm islands, and small embayments had the highest densities of fish and largest variety of species.

Together, these findings suggest that generally the most favorable condition for resident fish species in the Delta is a diverse environment consisting of a highly vegetated shoreline with ample backwater and shallow areas.

No-Action Alternative. In recent decades, resident fish habitat in the Delta has been changed substantially by two major factors, levee improvement and water project operations. Levee improvement activities have reduced the amount of emergent shoreline vegetation and riparian vegetation overhanging the water, thereby reducing aquatic cover, structure, and food supply required by most resident fishes.

Vegetation removal and bank armoring are considered harmful over the short term since most resident fish are associated with aquatic vegetation during all or part of their life cycle. Long-term effects depend on subsequent levee management. Resident fishes are abundant along old riprap where other habitat requirements are met, such as dead-end sloughs where there is aquatic vegetation fronting the levees and current velocity is low (DFG 1987). It is presently unknown how long a time period is required before habitat is established for fish to use. It is expected that levee improvement activities will continue in the future. These activities combined with routine waterside levee maintenance will be detrimental to many resident fish species.

Operation of the water projects has affected resident fish by: 1) altering flow patterns, which determine net channel velocities and distribution; 2) controlling salinity, which has influenced salinity levels and the abundance and distribution of food organisms; and 3) entraining fish at export facilities. None of these water project influences can be quantified with present knowledge. Actual losses of fish due to entrainment is not known for any of the resident fishes, but salvage rates provide an index of these losses. As exports rise in the future, salvage and loss are expected to increase.

Under the no-action alternative, losses of all resident species, including the Delta smelt which is now of particular concern due to its recent decline, will increase as exports increase. The effect of export facility losses on the total Delta population is currently unknown.

An increase in exports may result in increased entrainment of Delta smelt adult spawners in the winter-to-spring months and entrainment of larvae and young juveniles in the spring.

Increased exports anticipated under the no-action alternative will result in increased water velocities in some Delta channels. The increased velocities may increase the habitat suitability of affected channels for a few resident fish species, but decrease it for most.

Transport of some Delta smelt produced in the Sacramento River and other north Delta waterways to the entrapment zone will be impeded by diversions of water toward the central and south Delta. This will result in higher predation losses due to the longer period of passage, as well as a greater chance of entrainment in the pumping facilities.

Spawning habitat of some resident species requiring submerged vegetation will be temporarily lost due to ongoing flood control measures such as rip-rapping of levees in the north Delta. In the spring species such as the largemouth bass, golden shiner, splittail, and Sacramento sucker use land submerged by flooding for feeding habitat (Moyle 1976; DFG 1987). This type of habitat will be reduced by channelization and levee construction.

Under the no-action alternative, total annual Delta outflow will decrease slightly. This could result in an increase in the frequency of time when the entrapment zone will be upstream of Suisun Bay in the channels of the Delta. Location of the entrapment zone in the Delta channels results in a decrease in productivity (Williams and Hollibaugh 1987). Upstream movement of the entrapment zone would result in a decrease in the size and quality of the nursery area, thereby reducing the survival and growth of young-of-the-year Delta smelt and other native species with pelagic young.

Compared to present conditions, greater reverse flows under the no-action alternative will result in more larvae and juveniles being diverted toward the south Delta away from the entrapment zone.

Preferred Alternative. The preferred alternative will generally increase the proportion of Sacramento River inflow that is diverted through the Delta Cross Channel and Georgiana Slough (Table 5-12). This may have the effect of diverting more pelagic larvae of some native resident species that spawn above the Cross Channel. The diverted fish are probably more likely to be entrained in the CVP and SWP export facilities and are also less likely to reach the preferred nursery area in Suisun Bay. However, higher positive flows in the lower San Joaquin River should direct diverted fish back toward the nursery area rather than toward the export facilities, thus minimizing or negating the impacts of increased Delta Cross-Channel diversions. Fish spawned in the San Joaquin River below the mouth of the Mokelumne River will experience reduced reverse flow or higher positive flows (Table 5-19) which should improve their survival.

A combination of levee setbacks and channel dredging will be used to increase channel capacities in the northern and central Delta. The proposed levee setbacks are designed to create berm and shallow water areas where emergent and riparian vegetation can establish. In degraded shoreline areas the setback levees will provide improved habitat conditions (structure, cover, etc.) for many species. These miles of levee setbacks will increase the Delta habitat favored by most resident fish species. The opposite effect will occur in those few areas where vegetated berm and shallow areas are removed by dredging.

Other Alternatives. To some extent, all of the various NDP alternatives will increase the ratio of cross Delta flows (Table 5-12) and improve lower San Joaquin River flows. On balance, the effect of these changes on any of the resident fish species cannot be predicted with any reasonable degree of accuracy because there is insufficient knowledge of their habitat requirements in the Delta. The various alternatives vary in the extent to which levee cutbacks and dredging will be employed to improve channel capacities. In general, negative project impacts will be lowest where the use of levee setbacks is maximized and dredging is minimized.

Overview of Fish Food Supply Impacts

Fishery resources of the estuary are supported by a food web consisting of phytoplankton (algae), invertebrates, vertebrates, and detritus. The food web is dynamic; one organism feeds on another, and one food source is replaced by another with changes in season and the abundance and distribution of the food supply. Conditions that affect abundance and distribution of one link in the food web can affect the entire food web.

The general food habits of most species of fish inhabiting the estuary are known, but in most cases very little is known about the relationships between food organism density or production and the growth and survival of individual fish species. Nevertheless, the abundance and distribution of food organisms is thought to be an important factor in determining the overall health of the fish community in the estuary.

In the Sacramento-San Joaquin Delta, daily and seasonal changes in fresh and sea water, tides, winds, and currents interact with the food web. The complex interaction of these factors with the food web is difficult to understand; hence, how the NDP may impact food supplies is mainly unknown.

Phytoplankton. Although some animals can consume detritus, phytoplankton are the primary basis of the aquatic foodweb in the estuary. These tiny, usually microscopic, single-celled algae use energy from the sun to convert simple inorganic molecules—such as carbon dioxide, nitrate, and phosphate—into the sugars, proteins, and fats required by herbivores in the estuarine foodweb. Clams, oysters, worms, and, most important, zooplankton depend on phytoplankton for their food supply.

Phytoplankton abundance in the estuary is controlled principally by the amount of light and nutrients available to sustain growth and reproduction, and, conversely, the amount of grazing they experience. Delta outflow also influences the abundance of phytoplankton in the upper estuary through its effect on the position of the entrapment zone. When Delta outflows are sufficient to position the entrapment zone adjacent to the shallows of Suisun Bay, where a greater portion of the water column is sufficiently penetrated by sunlight, phytoplankton production is greater.

Delta outflow also influences phytoplankton abundance through its effect on benthic grazers. Until 1988, during extended periods of low Delta outflow, marine grazers—

particularly the clam *Mya arenaria*—would become established in Suisun Bay, consuming a significant portion of the phytoplankton and reducing the food supply for phytoplankton. During the current four-year drought, a newly introduced clam, *Potamocorbula*, has become established in Suisun Bay in very high densities, replacing *Mya arenaria*. This new clam is though to have greatly reduced phytoplankton and zooplankton densities in Suisun Bay during 1988 and 1989. This reduced food supply for larval striped bass has significantly reduced their survival in 1989.

Phytoplankton, as determined by measuring chlorophyll *a*, has undergone a long-term decline. Recent IESP studies have indicated that chlorophyll *a* is the variable most often significantly related to variations in zooplankton and *Neomysis* abundance, suggesting that declines are due to a reduction in food supply.

The abundance of phytoplankton is affected by many interacting factors, including light penetration, residence time, water temperature, salinities, nutrients, and grazing by invertebrates. Attempts have been made to develop mathematical models for evaluating phytoplankton levels in the Delta and Suisun Bay region. Each model calculation uses input describing interrelationships among the physical, chemical, and biological factors that affect phytoplankton. Some of these inputs are channel geometry, flow distribution, dispersive transport characteristics, water quality variables, waste discharges, biological kinetic parameters such as phytoplankton growth rates, and physical parameters. Currently, the models are not sufficiently well developed to predict changes from water project operation.

Impacts on phytoplankton are unknown for the project alternatives because of lack of knowledge of the cause-and-effect relationship of export pumping, and the uncertainty of the mathematical models in projecting abundance levels.

Invertebrates. Numerous invertebrate species of zooplankton (animals drifting in the water column or with limited swimming capacity) and zoobenthos (animals living on or in the substrate) inhabit the estuary. Both are important as food for many fish, including the juveniles of many gamefish.

Zooplankton is a general name for small aquatic animals that constitute an essential food source for fish, especially young fish and small forage fish. Generally, zooplankton feed heavily on phytoplankton and thus transfer the energy of primary production to higher trophic levels.

High crustacean zooplankton abundance (copepods and cladocerans) is associated with low salinities, high chlorophyll (a phytoplankton), and low net velocities in Delta channels. Copepods4 are also associated with high salinities. Zooplankton populations are highest during summer. The opossum shrimp, *Neomysis mercedis*, an important part of the estuary's food web, is a food of young striped bass. Normally, more than 60 percent of the *Neomysis* population of the estuary is found in the Suisun Bay area, with much of the remainder found in the west Delta. Since the 1976–1977 drought, *Neomysis* populations in Suisun Bay have partially responded to the increased Delta outflows that have occurred in recent wet years. However, outflows from 1978 to 1981 have had little positive effect on *Neomysis* in the San Joaquin River.

Salinity is the primary regulator of the distribution of zooplankton species in the estuary. In the upper part of the estuary, there are both fresh water and estuarine zooplankton. The fresh water zooplankton fauna is dominated by the cladocerans, *Daphnia parvula* and *Bosmina longirostris*, and copepods of the genera *Diaptomus* and *Cyclops*. An introduced Chinese copepod, *Sinocalanus doerii*, appears to be a fresh water species that ranges into the entrapment zone.

The most important zooplankton species are the native copepods, *Eurytemora affinis, Acartia californensis, and A. clausi*. *Eurtemora* reach their greatest abundance in the entrapment zone and extend into fresh water, while the *Acartia* are most abundant downstream of the entrapment zone. The shrimp, *Neomysis mercedis*, is concentrated in the zone of surface salinities ranging from 1.2 to 4.6 ppt.

There has been a long-term decline in abundance of all native zooplankton in the upper estuary, with the exception of the copepod *Acartia* and the shrimp *Neomysis*. Three accidentally introduced Asian copepods have helped maintain total copepod populations, but one recently introduced species, *Sinocalanus*, may have detrimentally affected the abundance and distribution of *Eurytemora*, which is the principal food for the youngest striped bass and perhaps other larval fishes (Figure 5-26). *Pseudodiaptomus* is another recently introduced species.

Two amphipods, *Corophium stimsoni* and *Corophium spinicorne*, are important constituents of Delta zoobenthos. They are the principal food for sturgeon, white and channel catfish, tule perch, and small black crappie, and are

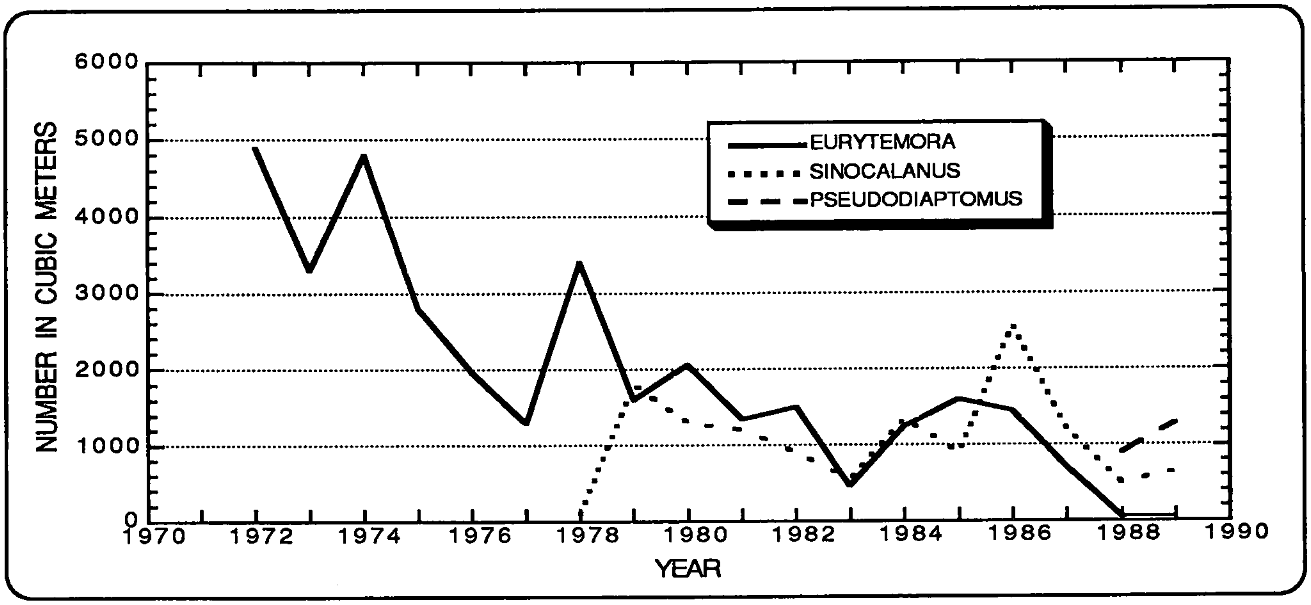


Figure 5-26. Mean March to November Abundance of *Eurytemora, Sinocalanus, and Pseudodiaptomus* *from 1972 to 1989*

also the second most important food of young striped bass. Other abundant benthic organisms are the Asiatic clam, tendipedid larvae, oligochaete worms, and crayfish. All are eaten by Delta fish, but none is as important as *Corophium.*

Important elements of the Interagency Ecological Study Program for the Sacramento–San Joaquin Estuary are:

- monitoring the abundance of *Neomysis* and other zooplankton in the Delta and Suisun Bay.
- analyzing factors affecting their abundance.

The analysis has focused on *Neomysis* because of its importance and because a larger data base is available.

DFG biologists have developed a multiple regression for calculating a *Neomysis* abundance index that explains about 96 percent of the *Neomysis* abundance during the medium- and low-flow years 1972 to 1981. However, in the very high-flow year of 1983, the predictions were much higher than the levels observed. The multiple regression parameters and their importance are shown in Table 5-28.

Of the many zooplankton species examined by the IESP all have their distribution affected by Delta outflow and its influence on the salinity gradient, but only *Neomysis* has its abundance affected. Analysis of zooplankton abundance in Old River indicates that abundance is unrelated to volume of export pumping at CVP and SWP export facilities. However, zooplankton abundance in the San Joaquin River at the mouth of Old River appears to be reduced by cross-Delta flow to the export facilities. Cross-Delta flows are thought to reduce zooplankton abundance by lowering residence times in Delta transport channels and diverting water with lower zooplankton densities into the central Delta.

Impacts of NDP. The following assessment of effects of the alternative operational plans on aquatic invertebrates is based on present knowledge of their abundance and distribution, and of the effects of water project operation.

No-action Alternative. Aquatic invertebrates are affected by water diversions by altering outflows, salinities, and tidal flows and velocities in Delta channels. Flows in Delta

Table 5-28
Characteristics of Regression of *Neomysis* Abundance Index

Variable	Percentage of Variance Explained
Salinity	71.3
Abundance of *Eurytemora*	21.4
Chlorophyll a	3.4
Water Diversions	1.5

channels are affected by operation of the Delta Cross-Channel gates. Some general effects follow:

- Project operations reduce fresh water zooplankton in the reach of the San Joaquin River below the Mokelumne River by introducing Sacramento River water with low plankton densities into this area.
- Salts drawn into this reach of the San Joaquin River by pumping tend to depress fresh water plankton and increase the abundance of brackish water species, especially *Eurytemora*, a copepod. *Neomysis* and young striped bass graze on *Euretemora.*
- Pumping entrains aquatic invertebrates.
- Project operations can reduce spring Delta outflow, which, in turn, may reduce phytoplankton production by both enhancing conditions for marine benthic grazers and driving the entrapment zone upstream from Suisun Bay.

Under the no-action alternative, the pattern of exports will not change. The extent of the effect of these exports on invertebrates is not clear. Water export diversions are the least important of four factors affecting overall *Neomysis* abundance.

Preferred Alternative. Exports under this alternative are reduced from May through August and increased for the remaining months. This change in the timing of exports should be beneficial to *Neomysis.* With reduced exports during the summer, incremental effects on tidal flows and velocities in Delta channels should not be adverse.

In comparison to the no-action alternative, outflow levels under the preferred alternative will be slightly lower during some spring months of critical and dry years. Spring outflow levels will be very similar between the two alternatives in other year types.

The preferred alternative increases the diversion of Sacramento River water into the central Delta at times when the Delta Cross-Channel is open, which will likely further reduce the abundance of zooplankton in the central Delta at those times. The reduction in reverse flows in the lower San Joaquin River achieved by the preferred alternative will repel salinity in this reach and may increase the abundance of fresh water zooplankton there.

Other alternatives. The other alternatives are very similar to the preferred alternative with respect to their effects on average monthly exports and outflow. They do vary considerably in the extent to which they increase Sacramento River diversion and reduce reverse flow, but the variation in impacts associated with these differences are not distinguishable with the current level of knowledge of zooplankton dynamics.

Overview of Direct Impacts of the Delta Complex on Fish

Direct impacts of the Delta Complex on fish cannot be closely correlated to overall Bay-Delta fish impacts because of a lack of information on losses that normally occur during all life cycle stages. Direct impacts are only one component of an overall assessment. The previous general impact assessment for overall fish impacts was made qualitatively and considered direct impacts.

Direct impacts are considered to begin when SWP diversions entrain fish into Clifton Court Forebay. Fish more than about 1 inch long are subject to screening from the export water at the John E. Skinner Delta Fish Protective Facility and are captured, transported, and released back to the west Delta, generally beyond the influence of the project diversions. Fish too small to be screened, such as eggs and larvae of striped bass, and fish not effectively screened pass into the California Aqueduct with the export water.

Those fish not diverted by the primary louvers either die passing through the pumping plants or survive in the aqueduct system and reservoirs. A substantial fishery is supported by the aqueduct and reservoir system and is an acknowledged benefit. The fishery is a combination of stocked fish and fish exported from the Delta.

Direct Losses of Eggs, Larvae, and Juvenile Striped Bass due to SWP Pumping

Pumping from the south Delta by the SWP results in the direct loss of striped bass and other fish due to entrainment, predation, handling, and hauling. This section describes analyses related to the potential impacts of constructing and operating North Delta facilities on these losses.

Before discussing the analyses themselves, it may be helpful to provide a brief background on how losses occur at the facility and what has been done to minimize or offset these losses. Figure 5-27 is a schematic diagram of the Skinner Fish Facility.

Fish enter the Forebay through the radial gates which are opened periodically near high tide to maintain water levels in the 31,000-AF regulatory reservoir. Some predation occurs as the fish move across the Forebay to the Canal intake. A set of primary louvers guides fish to bypasses leading to secondary screening systems. These devices separate fish from water and move the screened fish into holding tanks. Efficiency of the screening process depends on such factors as channel velocity and fish size. Fish going through the louvers into the aqueduct are lost to the Bay/Delta but do help support an extensive fishery in the aqueduct and project reservoirs.

The holding tanks are used to collect and count fish. When enough fish have accumulated in the tanks, they are transferred to fish hauling trucks and transported to the Sacramento River for release at locations away from the draft of the pumps. Losses of striped bass occur in the holding tanks and in the transport trucks.

Over the years, but especially in 1982 and 1983, changes in facilities and operations have been made to increase the efficiency of fish protective measures at the facility. Among these measures are:

- establishing velocity and bypass ratio operational criteria to maximize screening efficiency (these criteria are different for chinook salmon and striped bass);
- opening more channels and installing center dividers in all channels to improve striped bass screening efficiency;
- adding a new perforated plate secondary system to improve screening efficiency in the secondary and to allow for better velocity control in the primary louvers;
- rescreening holding tanks with finer mesh to reduce losses in the tanks; and
- reducing hauling–related stress through better aeration and the addition of small amounts of salts to the water.

In addition, DWR is proceeding with the construction of three more holding tanks, which will be used to reduce velocities in the tanks (and reduce losses), help make better use of both secondaries, and help improve the accuracy of the counts of salvaged fish.

Analysis of 18 years (1969–1985) of historical data has shown that salvage of striped bass at the Banks Pumping Plant from June through August is correlated with the following factors:

- flow in the lower San Joaquin River,
- total abundance of young striped bass in the Delta,

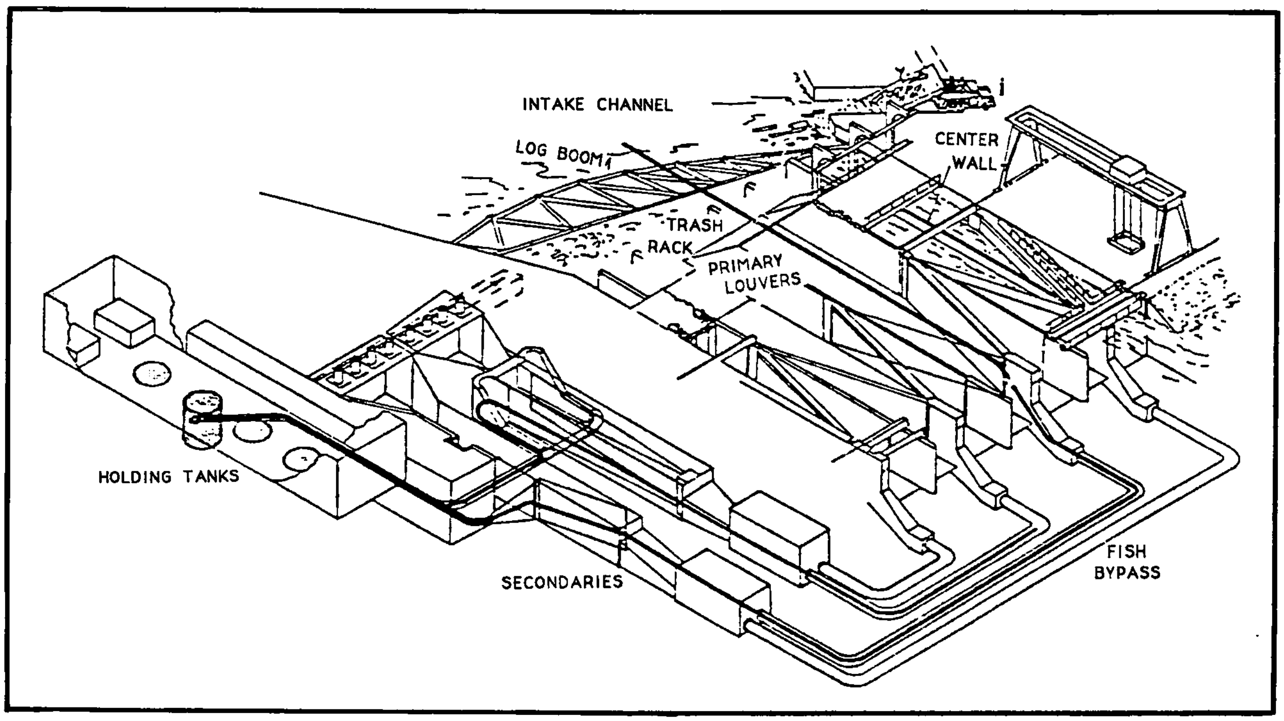


Figure 5–27. Schematic Diagram of the John E. Skinner Fish Protective Facility

- mean size of salvaged striped bass, and
- combined exports of the federal Central Valley Project and the State Water Project.

The correlation of these factors with salvage were used to develop a model of salvage loss at the Banks Pumping Plant. As used here, the term "salvage loss" refers to losses of striped bass greater than 18 mm at the Skinner Fish Facility, as estimated from salvage operation records. It includes those fish lost by passage through the facility's screens, hauling and handling, and an adjustment for some predation losses in Clifton Court Forebay. (A detailed description of the development, use, and limitations of this model is provided by Wendt, 1987.)

The salvage loss model was used to evaluate the potential effects of the no action and NDP alternatives on the salvage losses of striped bass at the pumping plant from June through August (Table 5-29). Estimates of total exports and flow in the lower San Joaquin River from operation studies were combined with information on historical (1968-1978) striped bass abundance and size data and applied to the salvage loss model to estimate salvage losses that would occur in June-August with each of the alternatives.

Caution should be used in interpreting the results of any predictive model. For this model particular care should be taken not to over emphasize the importance of the specific values predicted for the abundance of losses resulting from the implementation of any of the alternatives. The magnitude of these values will vary significantly depending on the specific assumptions used to develop or to use the model. As new information is developed, some of these assumptions will be found to better reflect actual conditions than other assumptions. For this reason, emphasis is more properly focused on the relative difference in salvage losses between the no action and project alternatives. These relative differences are generally less sensitive to the specific values assumed for the rate of predation or salvage for example.

Table 5-29.
Estimated Average Salvage Losses of Striped Bass Longer than 18 mm at the Skinner Fish Facility in June Through August

	Critical		Dry		Below Normal		Above Normal		Wet		Overall **	
Alternativ	Total Loss	Relative Change *	Total Loss	Relative Change	Total Loss	Relative Change	Total Loss	Relative Change	Total Loss	Relative Change	Total Loss	Relative Change
No-Action	3000	--	6800	--	7500	--	7600	--	3400	--	4600	--
2A	3100	+3	7200	+6	7100	-5	7100	-7	3100	-8	4500	-2
2B	3000	--	6700	-1	6600	-12	6500	-14	3200	-6	4300	-7
3A	3100	+3	7200	+6	7000	-7	6900	-9	3100	-9	4400	-4
3B	2900	-3	6500	-4	6500	-13	6400	-16	3200	-6	4300	-7
4A	3100	+3	7100	+4	6900	-8	6900	-9	3100	-9	4400	-4
4B	2800	-7	6300	-7	6500	-13	6300	-17	3200	-6	4300	-7
5A	3100	+3	7100	+4	6900	-8	6900	-9	3100	-9	4400	-4
5B	2800	-7	6300	-7	6500	-13	6300	-17	3200	-6	4300	-7
6A	3100	+3	7000	+3	6800	-9	6800	-11	3200	-6	4300	-7
6B	2700	-10	6200	-9	6400	-15	6300	-17	3200	-6	4300	-7

* Negatives indicate a reduction in striped bass salvage losses.

** Overall loss estimates are calculated using weighted numbers based on the number of critical, dry, below normal, above normal, and wet water years during the period of record (1968-1978).

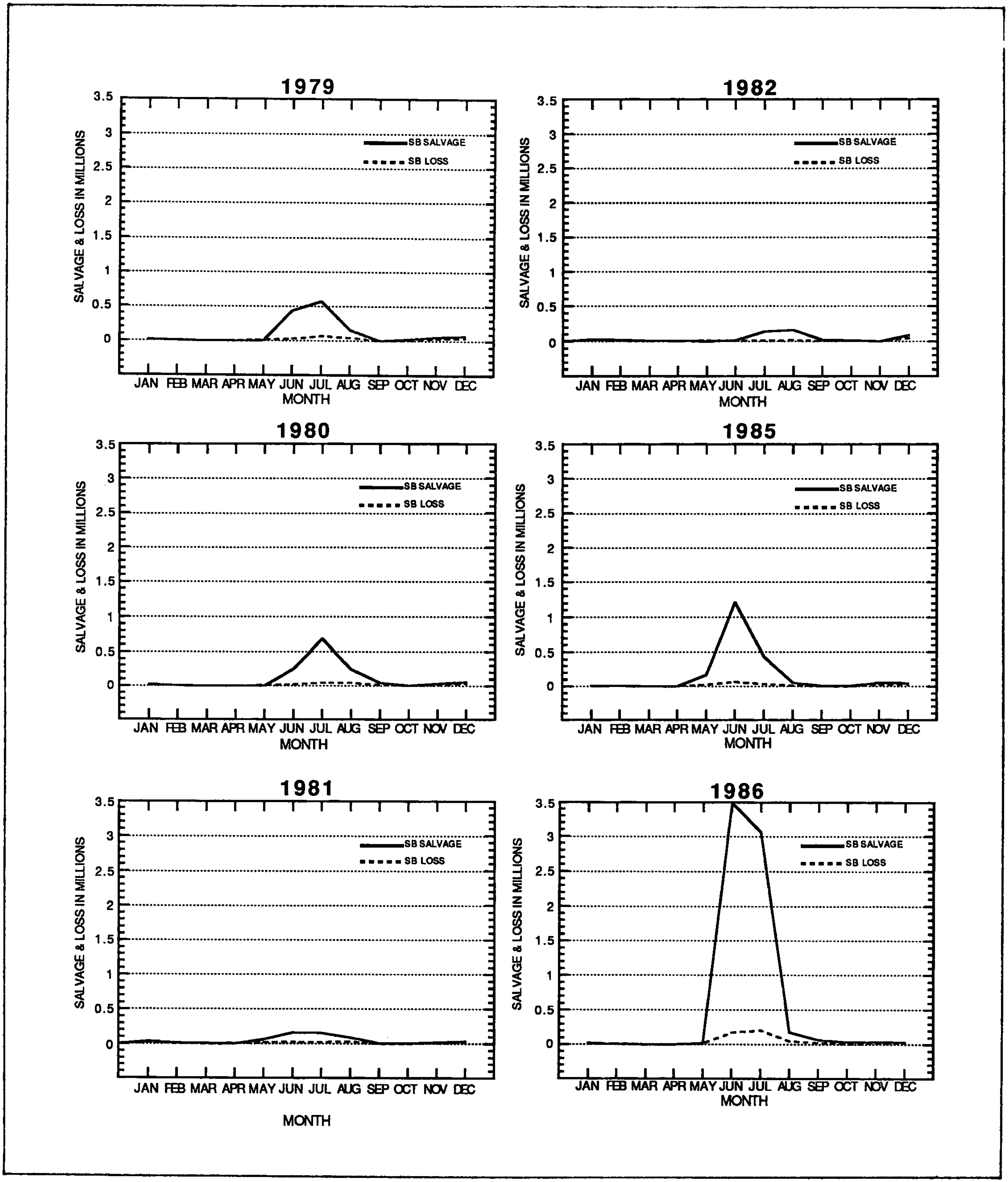


Figure 5-28. Annual Cycle of Striped Bass Salvage in Yearling Equivalents

The modeling results indicate that at least from June through August the losses of striped bass longer than 18 mm at the Banks Pumping Plant would be 2–7 percent less with the NDP alternatives than with the no action alternative. As shown in Figure 5–28, most of the losses of striped bass have occurred during this three-month period. The reduction in striped bass losses is attributable to the increase in downstream flow in the San Joaquin River and occurred in spite of a general increase in pumping with the NDP alternatives.

As described elsewhere in this report, in 1986 DWR signed an agreement with DFG to offset the direct losses of striped bass, chinook salmon, and steelhead rainbow trout at the California Aqueduct intake. Under terms of this agreement, DWR is implementing programs that result in increased numbers of yearling striped bass in the Bay/Delta.

Projects approved to date include purchase of hatchery striped bass, growing wild fish salvaged at the screens to yearling size, and screening a diversion in Suisun Marsh. To the extent that the decline in striped bass abundance is due to the physical process of entrainment (and not to changes in habitat), significant increases in the number of yearlings should result in an increase in numbers of adults. Early results indicate that yearlings planted in the Suisun–San Pablo Bay area are experiencing good survival to adults.

Direct Impacts of the Delta Complex on Chinook Salmon

The fish loss model described previously for striped bass was used to compare projected Chinook salmon losses under the No–action and preferred alternatives. As with striped bass, the model uses salvage numbers and system losses (trucking, handling, losses through louvers and predation in Clifton Court Forebay) to calculate total fish losses. A major difference in the assumptions in the model when used to estimate salmon losses as opposed to striped bass losses is that the assumed Clifton Court predation loss for salmon is 75 percent for all sizes, while it is size-dependent for striped bass. Also, trucking losses are assumed to be near zero for Chinook salmon. When using the model to estimate either striped bass or salmon losses, estimates of losses should be used only to assess relative differences in losses between alternatives.

All four races of Chinook salmon are included in these estimates. Although the majority of downstream migrants are typically captured in the April through June period, some salmon are salvaged during all months of the year. The different races of salmon cannot be differentiated at this time; however, it can be assumed that the majority of fish being salvaged are from the fall run given the relative size of the four salmon runs. Also, it is likely that most of the fish are from the San Joaquin system, although the exact breakdown varies annually and seasonally.

As shown in Table 5–30, the preferred alternative resulted in slightly greater calculated Chinook salmon losses compared to the no–action alternative. Considering the degree of accuracy of the assumptions involved in the modeling, the losses due to preferred and No–action alternatives are essentially the same. For comparison purposes, the calculated historic total loss during the 1979 – 1987 period was 4,321,898 yearling equivalent Chinook salmon.

The reduction in reverse flows for the preferred and other alternatives actually reduces the number of salmon enter-

Table 5–30
Calculated Losses (Yearling Equivalents) of Juvenile Chinook Salmon at the NDP Export Facilities, 1980–1987, for the NDP Alternatives

		Calculated Losses for each Alternative in 1000s and the Percentage Difference from No–action Alternative[1]																						
	Year	1	2A		2B		3A		3B		4A		4B		5A		5B		6A		6B	
Year	Type	No.	No.	.Δ%	No.	Δ%	No.	Δ%	No.	Δ%	No.	Δ%	No.	Δ%	No.	Δ%	No.	Δ%	No.	Δ%	No.	Δ%
1980	WET	612	631	3	635	4	633	3	636	4	633	3	636	3	633	3	636	4	634	4	636	4
1981	DRY	277	279	1	281	1	280	1	281	1	280	1	281	1	280	1	281	1	280	1	281	1
1982	WET	1450	1450	0	1450	0	1450	0	1450	0	1450	0	1450	0	1450	0	1450	0	1450	0	1450	0
1983	WET	983	982	0	982	0	982	0	982	0	982	0	982	0	982	0	982	0	982	0	982	0
1984	WET	295	296	0	296	0	296	0	296	0	296	0	296	0	296	0	296	0	296	0	296	0
1985	DRY	394	399	1	405	3	402	2	406	3	404	3	408	4	404	3	408	4	402	2	408	4
1986	WET	1330	1370	3	1350	2	1370	3	1330	0	1370	0	1270	-5	1370	3	1270	-5	1370	3	1230	-8
1987	DRY	219	232	6	240	10	235	7	242	11	235	7	242	11	237	8	242	11	237	8	242	11
TOTAL		5560	5640	1	5639	1	5648	2	5623	1	5560	2	5565	0	5652	2	5565	0	5651	2	5525	-1
Avg. % change				1.4		1.4		1.6		1.1		1.6		0		1.7		0		1.6		-0.7

[1]Δ% = Percent change in calculated losses of juvenile Chinook salmon. Negative numbers indicate a reduction in losses.

ing Clifton Court Forebay from May through July, which is the time when most of the salmon are migrating through the Delta. Since fewer fish are entrained, the preferred alternative should reduce salmon losses when compared to the no-action alternative.

It is expected that the operation of the barrier-type facility at the head of Old River will cause most of the downstream migrating San Joaquin River Chinook salmon to move down the San Joaquin River past Stockton into the central Delta instead of being drawn across Old River or Grant Line Canal. While some of these salmon will be entrained by the cross Delta transfer of water back toward the pumping plants, it is expected that the strong tidal action into the central Delta channels will draw a large number of smolts toward the downstream bays and the ocean.

Direct Impacts of the Delta Complex on Other Fish Species

Estimates of direct impacts for species other than salmon, steelhead, and striped bass were based on salvage at the John E. Skinner Fish Protective Facility. Historical salvage densities used in this analysis were calculated from 1968 through 1980 (DFG 1981). The approach used here provides a relative comparison of salvage under the alter natives considered. It is not intended to predict actual levels of future salvage. Average annual salvage estimates were derived by multiplying projected monthly average exports by historical monthly average salvage densities. Such estimates account for monthly abundance, but not for the many other factors considered in the analyses of striped bass and Chinook salmon, such as fish screen efficiency and losses from predation, handling, and hauling. Estimates of these factors for other species are not available.

The salvage estimates provided here are intended to be used as indices of loss. Loss estimates for salmon, steelhead, and striped bass were expressed in terms of "yearling" or "smolt" equivalents. This approach requires estimates of mortality that would have occurred between the time a fish is lost and the times it becomes a yearling or smolt. The estimates of mortality necessary for making yearling equivalent adjustments are not available for other species. Therefore, the salvage estimates in Table 5-31 are simply expressed as numbers salvaged.

Calculated salvage numbers of other fish species are shown in Table 5-31. As salvage estimates increase, total direct losses also increase since the salvage process is less than 100 percent efficient. As salvage estimates decrease, total direct losses also decrease.

Impacts of the NDP

No-action Alternative. Under the No-action alternative, the total computed salvage for selected anadromous fish other than striped bass, salmon, and steelhead is 1,548,408, of which 99 percent are American shad. The total for resident game fish is 1,468,788, of which about 94 percent are white catfish. The total for resident nongame fish is 4,791,644, of which about 69 percent are threadfin shad.

The estimated levels of salvage associated with the no-action alternative are related to the quantities of water exported by the SWP. In response to increasing demand levels, the no-action alternative exports are generally higher than those of the recent past. By extension, relative salvage (and loss) levels are greater under the no-action alternative than would have occurred under export levels of the recent past.

Preferred Alternative.

Estimated salvage under the preferred alternative is higher than under the no-action alternative for all species. The increases range from 1.3 percent for largemouth bass to 10 percent for green sturgeon. The changes in estimated salvage are a function of both the increase in mean annual exports under the preferred alternative and the monthly distribution of exports. Where the increases in salvage are relatively large, it suggests that exports have tended to increase during months of historically high salvage density. Conversely, relatively low increases indicate that exports increase during months of low salvage density.

Other Alternatives.

The other NDP alternatives are expected to have similar monthly export schedules. This would suggest that, all other things being equal, salvage levels would be similar to those of the preferred alternative. However, the alternatives vary in how they distribute Sacramento River water that has been diverted through the Delta Cross-Channel. These differences may affect the distribution of such species as American shad, which are diverted along with Sacramento River water, changing their susceptibility to entrainment. Data that would enable predictions of how the various alternatives will affect the distribution of fish, and thus their susceptibility to entrainment, are not available.

TABLE 5–31
Calculated and Direct Average Annual Salvage of Screenable Size Fish
Other than Striped Bass, Chinook Salmon, and Steelhead Rainbow Trout at the Delta Complex[1]

Species	No-action	Preferred Alternative	Percent Change Over No-Action[2]
Anadromous Fish			
American Shad	1,543,452	1,640,004	+6.26
White Sturgeon	3,516	3,852	+9.56
Green Sturgeon	1,440	1,584	+10.00
Resident Game Fish			
White Catfish	1,383,768	1,470,636	+6.28
Channel Catfish	37,320	38,212	+5.34
Black Crappie	25,056	26,280	+4.89
Bluegill	11,400	12,048	+5.68
Starry Flounder	4,788	4,968	+3.76
Largemouth Bass	6,456	6,540	+1.30
Resident Non-Game Fish			
Hitch	4,956	5,088	+2.66
Threadfin Shad	3,328,104	3,629,364	+9.05
Sacramento Splittail	166,812	169,584	+1.66
Hardhead	20,484	21,012	+2.58
Carp	32,400	33,540	+3.52
Bigscale Logperch	8,208	8,376	+2.05
Longfin Smelt	92,268	94,080	+1.96
Delta Smelt	899,700	924,684	+2.78
Prickly Sculpin	123,768	125,904	+1.73
Yellowfin Goby	112,376	116,004	+2.32
Sacramento Blackfish	2,568	2,712	+5.61

[1]Calculations of annual fish losses changing with salvage, based on data from DFG report, *The John E. Skinner Delta Fish Protective Facility, 1968–1980, A Summary of the First Thirteen Years of Operation*, October 1981. Values are in fish per year.

[2]Positive numbers indicate an increase in fish losses with the proposed action.

For any of these species, it is difficult to equate salvage and loss estimates to impacts on the population as a whole. This is due to normal losses occurring during the life cycle from other causes or to possible compensatory mechanisms that might allow the effect of losses to be reduced. Unfortunately, insufficient data are available to identify or measure compensation for these species in the Delta.

Some species, such as sturgeon, Pacific lamprey, and tule perch, are salvaged rather infrequently, although they are present in fair numbers in the Delta. Others, such as starry flounder and brown bullhead, are salvaged infrequently because the south Delta is not their preferred habitat. Species such as American shad, white catfish, and threadfin shad maintain high populations in the Delta despite significant annual entrainment.

The significance of the increases in salvage, and presumably losses, identified in Table 5-31 undoubtedly varies among the species listed. Although compensating mechanisms may be at work in the Delta environment, it is likely that the estimated increases in salvage will have some negative impacts on the fish populations.

Impacts on Wildlife and Wildlife Habitat

Wildlife impacts and compensation needs of the NDP from enlarging north Delta channels were estimated, using the USFWS Habitat Evaluation Procedures (HEP), a methodology that can be used to document the quality and quantity of available habitat for selected wildlife species.

HEP is endorsed by DFG as a means of rating the quantity and quality of habitat to evaluate proposed mitigation. HEP provides information for two general types of wildlife habitat comparisons:

- the relative value of different areas at the same point in time;
- the relative value of the same area at future points in time.

By combining the two types of comparisons, the impact of proposed or anticipated land and water use changes on wildlife can be quantified.

The application of HEP is based on the assumption that habitat for selected wildlife species or communities can be described by a model that produces a Habitat Suitability Index (HSI). The HSI value, from 0.0 to 1.0, is multiplied by the area of available habitat to obtain Habitat Units (HUs), which are used in the comparisons described above.

The USFWS completed the HEP report (October 1990). A summary of the analyses and results is incorporated in Appendix G, USFWS's *Coordination Act Report Summary.*

Impacts on Wetlands

Enlargement of selected channels, using setback levees, will greatly increase the amount of habitat that can be listed as artificial wetland or emergent wetland. The additional channels created by the new setback levees will mitigate for any inadvertent loss that may result from construction of the new levee.

Impacts on Rare, Threatened, and Endangered Species

The results of field surveys for rare, threatened, and endangered plant and animal species are described in Chapter 4. The following species of plants and animals may be affected:

- Mason's *lilaeopsis,*
- California hibiscus,
- Delta tule pea.
- Suisun marsh aster
- Sanford's arrowhead

These five species of plants are found in the project area. There is a potential for the project to affect these species. When the exact location of the structural changes (dredging - channel enlargement) has been identified, results of the plant surveys will be checked to determine whether any protected plants are affected. Any significant impacts will be mitigated.

Barrier-type facilities will change water levels in the north Delta. The rise in mean water levels during low-flow periods will alter the vegetation in the narrow strip of land between the historic mean water level and the new higher mean water level. Plants in this zone are subjected to daily and seasonal fluctuations in water levels.

Mason's *lilaeopsis*, an intertidal plant which, by means of rhizomes, colonizes new habitats, will re-establish itself quickly in the new intertidal zone. California hibiscus, occupying a broader and slightly higher zone than Mason's *lilaeopsis*, should also re-establish itself in a short time. The ability of both of these species to re-establish themselves will depend on the water level and duration of inundation at the new levels, which will be monitored. Mitigating actions will be taken as needed. The twelve populations of Delta tule pea in the project area will not be affected by any of the barrier-type facilities.

Swainson's hawk is the only terrestrial protected animal which may be disturbed by construction activities. Active nests will be avoided during the nesting period. Riparian areas produced by project implementation should provide additional habitat for the Swainson's hawk.

Suitable habitat for Aleutian Canada Geese was observed and sitings of greater Sandhill Crane were made within the project area. Because forage areas for these species change with annual variations in cropping patterns and rainfall, they should not be affected by the project or construction activities.

Four fish species merit special concern:

- Delta smelt, recommended for protection by California and the federal government;
- Sacramento splittail, recommended for protection by California and the federal government;
- Sacramento perch, recommended for protection by the federal government; and
- winter-run Chinook salmon, listed as endangered by California and as threatened by the federal government.

Some suitable habitat may exist in the project area for Delta smelt, but this habitat is probably not occupied. During most of the year, Delta smelt populations are found in the Sacramento River below Isleton, in Suisun Bay and Marsh, and down to Carquinez Strait and San Pablo Bay during high flow years. Smelt are also found in the San Joaquin River below Mossdale (Moyle 1976). Adults migrate and spawn in the shallow water of the upper Delta and in the Sacramento River above Rio Vista during late winter and spring.

Some Delta smelt could be diverted at this time. During the winter and some spring months, river flows are generally high and the Delta Cross-Channel gates are closed, which should generally result in good through-Delta survival. During dry, critical, and below-normal years, SWP and CVP pumping should result in the loss of some Delta smelt at the pumps.

Sacramento splittail probably spawns in the portion of the Mokelumne River near the Interstate 5 bridge. Construction activities such as dredging will be scheduled to avoid spawning times. Sacramento perch is unlikely to occur in the project area due to its' possible extirpation even through suitable habitat is thought to exist.

Impacts to the winter-run Chinook salmon are discussed in the following section.

Winter-Run Salmon Impacts. The winter-run of Sacramento River chinook salmon has been listed as endangered by California and as threatened by the federal government. It is a unique race of salmon which spawns in the May-August period in the upper Sacramento River between Red Bluff and Keswick Dam. Spawning, incubation and juvenile rearing take place during summer months when water temperatures are typically warm in the upper Sacramento River. Before the construction of Shasta Reservoir, the winter run spawned in the cool reaches of the McCloud River. Early operation of Shasta Reservoir caused colder temperatures in the upper Sacramento River and the spawning population of winter-run salmon increased to about 170,000 in 1969.

In 1989, the winter-run size was about 550 spawners. Many biologists believed that the dramatic decrease over the past 20 years has been due to the construction and operation of the Red Bluff Diversion Dam and an increase in spring/summer temperatures in the upper Sacramento River. The Dam itself caused delays in migration of adults upstream and juveniles downstream. Delayed migration of adults can result in less-than-optimum spawning, and a delay of downstream migrants leads to increased predation by squawfish and other fish. In addition, inadequate screens at the intake to the Tehama-Colusa Canal resulted in juvenile entrainment. Temperature problems were particularly severe in dry years when water released from Shasta Reservoir came from the warm upper layer.

Other factors that have been identified as adversely impacting populations include:

- impacts of acid mine drainage into the upper Sacramento River from the inactive Iron Mountain mine site in the Spring Creek watershed, which enters the Sacramento River immediately upstream of Keswick Dam;
- limited spawning gravels in the upper Sacramento River;
- fish losses due to entrainment at the Glenn-Colusa intake and other water diversion structures in the Delta; and
- commercial and sport harvest.

An interagency winter-run team has been established to develop a recovery plan. Much of this plan will be built around a cooperative agreement developed before the listing. This cooperative agreement was to implement actions to improve the status of winter-run chinook salmon. The cooperating agencies are DFG, USFWS, Reclamation, and NMFS.

The agreement contains the following actions:

- raise the Red Bluff Diversion Dam from December 1 through April 1;

- develop better water temperature control at the outlet from Shasta Reservoir;
- develop measures to control squawfish predation at Red Bluff Diversion Dam;
- correct Spring Creek pollution problem; restore spawning habitat in the Redding area;
- correct salmon-related problems at Anderson-Cottonwood Irrigation District Diversion Dam;
- restrict in-river harvest of winter-run chinook salmon;
- develop a winter-run chinook salmon propagation program at Coleman National Fish Hatchery;
- modify the Keswick fish trap to prevent mortality to winter-run chinook salmon;
- continue and expand studies on winter-run chinook salmon; and
- develop fish ladders as an alternative to raising the Red Bluff Diversion Dam gates.

The potential impacts of NDP on winter-run salmon would occur during their passage through the Delta as downstream migrants. The time when winter-run outmigrants are in the Delta is not well defined but DFG believes that peak abundance is in the January through March period. During the winter months, river flows are generally high, temperatures cold, the Delta Cross Channel gates are closed, and local agricultural diversions are minimal. Although this combination of factors should generally result in good through-Delta survival, there have been no studies specifically designed to estimate survival of winter-run smolts.

During dry, critical, and below normal years, river flows are generally low even during winter months. SWP and CVP pumping may result in some winter-run juveniles being lost at the pumps. There is no definitive means of distinguishing a winter-run juvenile from one of the other three races of salmon present in the Central Valley system. DFG has developed a size relationship that may help differentiate the salmon.

The recovery plan now being developed will help with implementation of both the federal and State acts. The recovery team has met only once so far. DWR is to be a member of the team. In addition, DWR has initiated a consultation process with NMFS and DFG on the potential impact of the preferred alternative on winter-run salmon. DFG will be consulted for written findings on the impact of the preferred alternative on the continued existence of the winter-run salmon, as required by CEQA and CESA. If it is determined that the preferred alternative results in a taking that is not permitted under either the federal or State act, DWR will work with the agencies to develop appropriate mitigation. Actions being considered include 1) participation in upstream measures that are critical to survival of the winter run, and 2) operational restrictions at the cross-channel gates when the juveniles are most vulnerable. Operation under the preferred alternative will not be conducted in a manner that would conflict with any requirements imposed on DWR by the State and federal acts.

Impacts on Tracy Pumping Plant Operations

The implementation of the NDP is not expected to affect the operation of Tracy Pumping Plant. Although the NDP will improve the diversion regime at the Delta by reducing carriage water requirements, the limited conveyance capacity of the Tracy Pumping Plant will not allow the CVP system to benefit from this added flexibility. Compared to the demands on the CVP system, Tracy Pumping Plant has a relatively small conveyance capacity. The projected CVP annual demands south of the Delta at the 2000 level of development is approximately 3.20 MAF as compared to the maximum conveyance capacity at Tracy Pumping Plant of 3.25 MAF. This limited conveyance capacity imposes an inflexible pumping schedule on Tracy Pumping Plant.

In addition to the above physical constraint there are institutional constraints, formulated in the Coordinated Operation Agreement (COA). The agreement calls for renegotiation of the sharing formula for water releases whenever either the CVP or SWP adds new facilities (Article 6 and 14a), and requires that the agency which constructs new facilities realizes the additional yield attributable to them (Article 16). The modeling studies to evaluate the performance of the NDP were conducted in accordance with these provisions of the COA. A simulation study of both systems were conducted without the NDP. This provided the simulation results for the no-action alternative (base conditions). The operation of the CVP system, including monthly diversions by Tracy Pumping Plant, was provided as input and remained constant in all subsequent simulation runs. Table 5-5 shows the average monthly diversions made by Tracy Pumping Plant in the simulation run for the no-action alternative and all the subsequent simulation runs that included the various alternatives of the NDP.

Impacts on Suisun Marsh

DWR and Reclamation planning includes protective measures for Suisun Marsh to mitigate for project development, including the NDP. With or without the proposed project, DWR and Reclamation will protect Suisun Marsh habitat with Delta outflow, physical facilities, a monitoring program, and a management program. The most important protective facility, the Suisun Marsh Salinity Control Gate Structure is already in operation.

Chapter 4 contains information on Suisun Marsh's physical characteristics, environmental importance, and multiagency preservation agreements. Protection for the marsh is designed to compensate for future projects, such as the proposed project. Evaluation of this protection can be found in the *Plan of Protection for the Suisun Marsh including Environmental Impact Report,* DWR, February 1984.

In the past, SWP and CVP operation and other upstream water use adversely affected the Suisun Marsh during dry and critical years. The reduction in outflow caused by upstream use and by export during October through May increased channel salinity within the marsh, which affected the composition and productivity of plant communities that are important food sources for waterfowl. Soil salinities in pond areas must remain within certain limits or habitat quality will deteriorate. If No-action was taken, the duration of salinity intrusion into the marsh channels would increase as greater amounts of water were diverted upstream and within the Delta. Seed production in the marsh would decrease, and less food would be available for waterfowl.

During the 1988–1989 water year, the Suisun Marsh Salinity Control Gates operated for 157 days (October 31, 1988 through April 7, 1989). Because of intermittent equipment problems, operations were recorded for 132 of the 157 days. During the 132-day period, the gates opened 268 times, for a total duration of 1,182 hours. Based on the recorded data, the gates tidally pumped 479,105 AF of water (averaging 3,630 AF, or 1,830 cfs per 24-hour day) into Suisun Marsh for the control season. During this same period, measured salinity levels in Suisun Marsh channels were lower than in any recorded similar hydrologic period.

The Suisun Marsh salinity control gates worked better than expected during this dry period. The 1987–88 water year had a Sacramento River Index of 9.2 MAF and was classified, according to Decision 1485, as critical. The 1988–89 Sacramento River Index was 15 MAF; therefore, this control season was considered a dry year for fish and wildlife standards. Channel water quality improved significantly as far west as the Volanti monitoring site on Suisun Slough. The improvements at Volanti occurred about seven days after the control gates began tidal pumping.

Table 5–10A summarizes monthly net Delta outflow for the north Delta alternatives, compared to the base condition. The table shows little change in monthly net Delta outflow, compared to the base. The NDP will have no significant impact on Suisun Marsh, because the Suisun Marsh program will protect the delicate balance of brackish water by a combination of Delta outflow, physical facilities, a monitoring program, and a management program.

In addition to the managed marsh areas within the Suisun Marsh, there are unmanaged marsh habitats around the perimeter of Suisun Bay. These unmanaged areas could be affected by the "pumping" of fresher water into Montezuma Slough, which would otherwise freshen the waters of Suisun Bay. These effects are now under study but insufficient data are presently available to either identify impacts or propose mitigation measures.

These studies will also provide information with which to evaluate the changes in outflow expected as a result of the NDP (Table 5–10 A). In general, outflow levels under the no-action alternative will decrease as SWP deliveries increase. Under the NDP, there will be slightly greater reductions in outflow during March through July of critical and dry years (Table 5–10 B).

Impacts on San Francisco Bay Aquatic Resources

Downstream of the Delta is a series of four shallow embayments linked by narrow channels. Together these embayments Suisun, San Pablo, Central, and South bays form the large estuary known as San Francisco Bay (Bay). In the Bay, ocean water passing landward through the narrow Golden Gate mixes with fresh water flowing seaward. About 90 percent of the fresh water entering the Bay flows through the Delta from the Sacramento and San Joaquin river drainages (USGS 1987). The circulation and mixing of these waters, in combination with the geology and bathymetry of the Bay, results in a highly diverse aquatic environment.

Fresh water inflow to the Bay is one of the principal factors determining the water quality characteristics and circulation of Bay waters. This fact raises concerns about the effects that water development may have on the Bay, be–

Table 5-32
Summary of Species Specific Differences in Catch-per-Unit-Effort (CPUE)
Between Wet (high-outflow) and Dry (low-outflow) years
During the Interagency Ecological Study Program's San Francisco Bay Study Sampling Program[1]

	WET		NO DIFFERENCE		DRY
	p< = 0.01	p< = 0.1	p>0.1	p< =0.1	p< =0.01
Freshwater Species					
	prickly sculpin splittail	threadfin shad threespine stickleback white catfish Delta smelt	bigscale logperch carp channel catfish tule perch		
Anadromous Species					
	chinook salmon green sturgeon striped bass white sturgeon	American shad	Pacific lamprey river lamprey steelhead		
Estuarine Species					
	Crangon franciscorum longfin smelt staghorn sculpin starry flounder yellowfin goby		*Palaemon macrodactylus*		chameleon goby
Marine Species					
	California tonguefish Pacific herring	leopard shark Pacific tomcod surf smelt dwarf perch	arrow goby barred surfperch bay goby bay pipefish big skate black perch bonehead sculpin brown rockfish brown smoothhound California lizardfish cheekspot goby *Crangon nigromaculata* curlfin turbot diamond turbot English sole lingcod *Lissocrangon stylirostris* northern anchovy Pacific sanddab pile perch plainfin midshipman rubberlip seaperch sand sole shiner perch showy snailfish speckled sanddab topsmelt spiny dogfish white croaker white seaperch whitebait smelt	walleye surfperch California halibut spotted cusk-eel	bat ray Pacific pompano *Crangon nigricauda* *Heptacarpus cristatus* jacksmelt

[1]Only the years 1980-1988 and the 70 most commonly caught species were included in the ANOVA analysis.

cause water development, along with reclamation and land use practices in the drainage, have changed the timing and magnitude of fresh water inflows. Because of these concerns, SWRCB requested in 1978 that the water development agencies conduct studies which would lead to a better understanding of the effects of fresh water inflow on the Bay's biota and provide information with which to set standards to protect the beneficial uses of the Bay (SWRCB 1978).

These studies are being implemented by the Interagency Ecological Studies Program (IESP). The biological component of these studies began in 1980, and the hydrodynamic component began in 1984. The IESP studies, in combination with other research, have not yet provided a detailed understanding of the complex relationship between fresh water inflow and the health of the Bay's biological community, but have provided evidence that fresh water inflow does play an important role in the life cycle of some species (DFG 1987).

The biotic community of the Bay reflects the diversity of habitats found there. More than 200 species of fish, shrimp, and crabs have been collected in the Bay during the IESP's sampling program. Ecological requirements vary considerably among the many species and life stages inhabiting the Bay. In the lower end of the estuary there are many common coastal marine species such as northern anchovy, the blue-spotted shrimp *(Crangon nigromaculata)*, and the speckled sanddab. For these species the more marine-like parts of the Bay appear to be an extension of their adjacent coastal marine habitat. Other species, such as the Pacific herring and batray, have adapted to using features of coastal embayments, such as mud flats or protected waters, not specifically associated with fresh water inflow.

Also inhabiting the Bay are such species as the longfin smelt, the bay shrimp *Crangon franciscorum*, and starry flounder. The life cycles of these species include specific adaptations for using Bay characteristics resulting directly from the inflow of fresh water. For example, the three species mentioned above are common inhabitants of the lower Bay and adjacent coastal waters as adults, but use the fresher parts of the Bay as their nursery area.

With the ecological requirements of Bay species varying so greatly, responses to variations in fresh water inflow would also be expected to vary. This is suggested by Table 5-32, which identifies 70 of the most commonly caught species in the IESP's Bay Study sampling program and categorizes them by differences in their indices of abundance in the Bay during wet and dry years (DFG unpublished data). The measure of abundance used in Table 5-32 is catch-per-unit effort (CPUE) in Bay Study sampling gear, which primarily captures organisms less than 2 years of age. For many species CPUE is not an index of total population size because the population may extend landward or seaward beyond the sampling area, which extends from the Golden Gate and South Bay to the lower Delta.

Species were placed in the "no difference" column when a general linear ANOVA showed no difference between years. For those species with a significant difference, CPUEs were average for wet and dry years, and used in ANOVA contrasting tests to determine placement in the appropriate column.

The CPUE of 39 out of 70 species is not significantly different in wet (high outflow) and dry (low outflow) years (Table 5-32). Among the marine species there is an almost even distribution of species that are significantly more abundant in either wet or dry years. Among the other three categories (fresh water, anadromous, and estuarine) there are clearly more species whose CPUE values are significantly higher in wet years than dry years.

For most of the species listed in Table 5-32, the mechanisms that drive the observed responses to outflow, and the significance of these observations to the populations of these species, are not well understood. For some of the fresh water species it is likely that low salinities due to high outflow can result in an expansion of their distribution into the Bay from upstream areas. Three of the anadromous species, white sturgeon, striped bass, and American shad, have been studied extensively, and it is known that year class strength is positively associated with levels of spring outflow. The associations and possible mechanisms are discussed in the individual sections of this report addressing each of those species.

Two estuarine species, longfin smelt and bay shrimp, have been studied in some detail to better understand why they have tended to produce larger year classes in wet years. Separate discussions of these two species follow:

Longfin smelt. The longfin smelt is a small (maximum size about 6 inches) species distributed as adults throughout the Estuary and occasionally into the Gulf of the Farallones. Year class strength varies dramatically, but when strong year classes are present, longfin smelt is one of the most abundant species in the Bay (DFG 1987). The Bay is the southern limit of this species' range, which includes several estuaries along the Pacific coast as far north as Prince William Sound, Alaska (Moyle 1976). California has at least two populations in addition to the Bay's population, one in the Eel River estuary and another in Humboldt Bay (Moyle 1976).

Mature adults nearing the end of their second year of life move from the Bay into the interior Delta, lower rivers, and fresh water marshes to spawn. Spawning takes place primarily during December through February. Most adults die after spawning, but a few females live a third year and spawn a second time (Moyle 1976). The eggs are adhesive and are deposited on aquatic vegetation and rocks. After hatching, the pelagic larvae are dispersed downstream by river flow. Generally, longfin smelt are concentrated in Suisun and San Pablo bays during the first 1.5 years of life, feeding primarily on *Neomysis mercedis.*

Measures of fall longfin smelt abundance are available from both the IESP's Bay Study and DFG's fall mid-water trawl survey. Analysis of the data from both of these programs suggest that year class strength varies considerably and is very strongly associated with the level of Delta outflow in the preceding late winter, spring, and summer (Stevens and Miller 1983 ;DFG 1987). These studies also indicate that survival between the larval and early juvenile stages determines year class strength (DFG 1987). Together, this evidence suggests that outflow influences year class strength through its effects on Bay conditions important to post larval longfin smelt.

The reasons for the positive association between juvenile survival and outflow are not well understood at this time, but outflow is known to affect the distribution of larval smelt. During years of high late-winter and spring out flow (e.g. 1982 and 1983) smelt are dispersed downstream into San Pablo and lower Suisun bays, whereas in lower outflow years (e.g. 1981 and 1985) larval smelt tend to be concentrated in both upper Suisun Bay and the lower Delta (DFG 1987).

The greater dispersal associated with higher levels of outflow may result in less intra-specific competition and higher survival. Variation in food supply associated with variations in outflow is another possible explanation for the observed associations between outflow and longfin smelt year class strength (Stevens and Miller1983), since the annual abundance of *Neomysis mercedis* and *Eurytemora* sp., both important zooplankton in the upper part of the Bay, is negatively correlated with salinity, which, in turn, is inversely related to outflow. The "Overview of Fish Food Supply" section of this chapter describes the factors influencing fish-food production in greater detail.

Bay Shrimp. There have been 14 species of true shrimp collected in the Bay by the IESP's Bay study program. Of these, the bay shrimp, makes up 84 percent of the total catch (Kathy Hieb, Fishery Biologist, DFG personal communication). The bay shrimp is now commercially fished only for bait, but in the past has been dried or used fresh for human consumption. Commercial catches peaked in 1935 at about 3.5 million pounds,but commercial demand has since fallen, and landings have been at about 250,000 pounds/year since 1957.

Bay shrimp are opportunistic feeders and consume many types of food items, including: mysids, amphipods, clams, copepods, polychaetes, crustacean larvae, fish larvae, insects, and plant material (DFG 1987). Bay shrimp are a food item for many fish species and are major prey item for striped bass, brown smooth hound, big skate, staghorn sculpin, white croaker and plainfin midshipman in the Bay (DFG 1987).

The bay shrimp uses the Bay and adjacent coastal waters to complete its life cycle. During fall and winter, egg carrying females migrate to marine areas of the Bay, mostly the central Bay, and to areas near the shore in the Gulf of the Farallones. After hatching, larvae migrate to the surface where, if they are in the Bay, they are swept out of the Golden Gate by seaward flowing surface flows. In the spring, when larvae are older and larger,they move down the water column and enter the Bay, possibly aided by landward-flowing bottom currents.

These late-stage larvae and juveniles, aided by landward flowing tidal and gravitational bottom currents, move from the central Bay towards the brackish water areas of the Bay, including such south Bay creeks and sloughs as Coyote Creek in the south, the creeks and rivers entering San Pablo Bay, and Suisun and Grizzly bays. There they spend the summer and fall months growing and mating to begin the cycle again. The spring recruitment of juveniles to the Bay and their subsequent survival determines year-class strength and, since they are short-lived, yearly population abundance.

The IESP's Bay Study provides a data base on bay shrimp abundance. During the first 9 years of Bay Study sampling (1980-1988), there has been a strong positive association between May through December abundance, as measured by Bay Study otter trawl CPUE, and March-May

Delta outflow, measured as flow past Chipps Island (Figure 5-29). The abundance index was calculated by the IESP's Bay Study and derived from catch data.

The positive association of March-May outflow levels with bay shrimp abundance is not well understood. A possible link is the effect of Delta outflow on the hydrodynamic patterns in the Bay. The gravitational currents created by salt water-fresh water density differences, combined with the large spring neap tides, not only cause large net landward flowing bottom currents that aid movement of shrimp into the Bay, but also increase the salinity gradient that could guide shrimp into the brackish nursery areas.

It is also possible that bay shrimp abundance is influenced by outflow-related differences in the size of the nursery area. In low outflow years, bay shrimp are distributed higher in the estuary, using more of the area upstream of Carquinez Strait and Suisun Bay. This shift in distribution is probably a response to the fact that salinities favorable to juvenile bay shrimp (2 to 20 percent) are located farther upstream in dry years. Generally, as outflow increases, the area of the Bay with salinity characteristics favorable to juvenile shrimp increases.

Impacts of NDP

With a few minor exceptions, water project facilities are located upstream and outside of the Bay so that their principal effect on the physical environment of the Bay is one of changing the timing and magnitude of fresh water inflow. About 90 percent of the fresh water inflow to the Bay enters as outflow from the Delta and is usually called Delta outflow. This chapter includes a general discussion of program impacts on Delta outflow.

Although water project related changes in Delta outflow and associated changes in certain outflow-related physical attributes of the Bay (e.g. salinity distribution) can be predicted with reasonable certainty, the ability to predict the biological consequences of those physical changes is presently limited. Impacts on white sturgeon and striped bass, both important species inhabiting the Bay, are discussed in individual species-specific sections of this chapter. Another section in this chapter discusses impacts on fish food supply and Bay productivity. Currently, there appears to be little basis for relating the abundance of many of the Bay fish and shrimp species to Delta outflow conditions. However, the populations of two species—the longfin smelt and the bay shrimp—appear to be responsive to flow. An assessment of the impacts of the No-action alternative and the NDP alternatives on longfin smelt and bay shrimp follows.

No-action Alternative. As discussed earlier, the abundance of longfin smelt and bay shrimp in recent years has been closely associated with levels of Delta outflow from late winter through early spring. In recent decades, there has been a general trend toward reduced Delta outflow levels

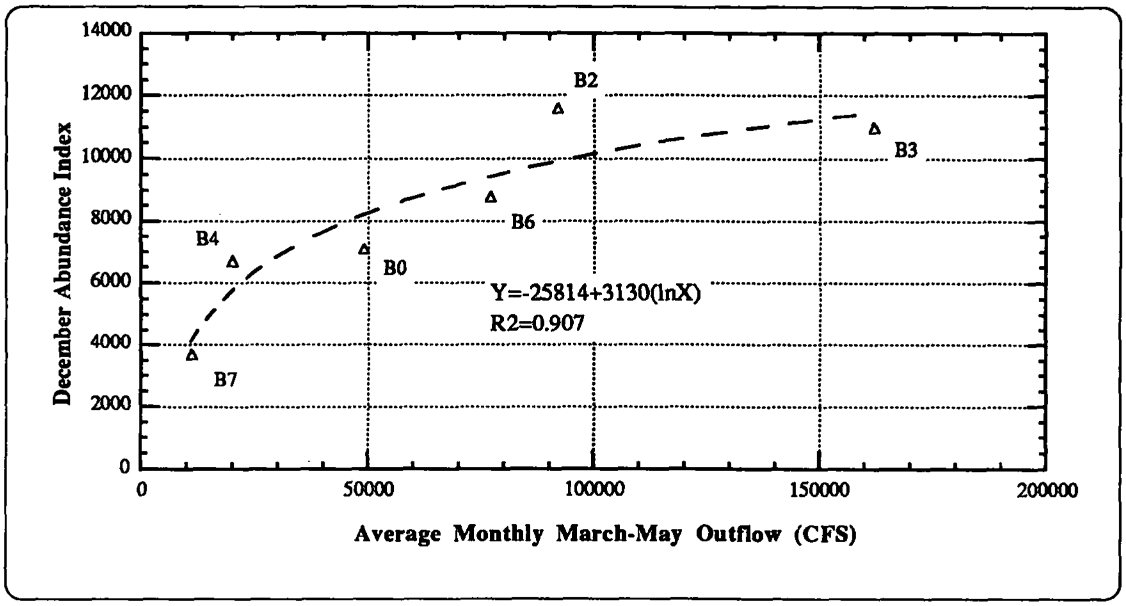


Figure 5-29. Correlation Between March-May Delta Outflow and May-December Abundance of *Crangon Franciscorum*

during late winter and spring caused by 1) construction and operation of upstream water storage reservoirs, which tend to capture streamflows during this period; 2) increasing consumptive use in the drainage tributary to the Bay; and 3) increasing CVP and SWP water exports from the Delta. It is expected that SWP export pumping under the No-action alternative will continue to increase, contributing, along with increases in upstream water development, to continued decreases in Delta outflow.

The observed interactions between Delta outflow and the abundance of longfin smelt and bay shrimp suggest that changes in Delta outflow in recent decades have reduced the abundance of those two species. In either case, historical measures of abundance are unavailable to accurately compare with current measures of abundance; however, anecdotal information on the magnitude of harvests by the commercial shrimp fishery early in the century suggests that the bay shrimp population has been reduced (Skinner 1962).

Preferred Alternative. As described above, it has been observed in recent years that fall measurements of longfin smelt year-class strength are closely associated with mean monthly outflow levels during the previous December through August. The closest association occurs during spring and early summer. On average, for all years of the 57-year period of record combined, mean monthly December-through-August outflow under the preferred alternative is about 1 percent less than it is under the no-action alternative (Table 5-10A). The relative change in outflow is greatest in the critical and dry years, for which mean preferred alternative outflows are 6 and 4 percent less, respectively, than the no-action alternative.

If, as recent observations suggest, outflow plays a positive role in longfin smelt production, the predicted reductions in outflow under the preferred alternative in the drier years would be expected to reduce production. The differences in dry- and critical-year outflows are relatively small during April through June. This period includes three of the four months when outflows and abundance are most closely associated, indicating that the reductions in abundance would be less than suggested by the changes in mean December-through-August outflow.

As previously discussed, the abundance of bay shrimp in San Francisco Bay is closely associated with mean monthly March-through-May outflow. As shown in Table 5-10A, the preferred alternative alone is expected to have very minor effects on mean monthly outflow levels during March through May in most year types. The largest change occurs in March of critical years, when mean monthly outflow is reduced by 4 percent, relative to the no-action alternative. This 4 percent reduction in critical-year March outflow results in only a 1 percent reduction in mean outflow for March through May of critical years.

Other Alternatives. The various NDP alternatives have very similar effects on Delta outflow. For this reason, the expected impacts of the other alternatives on Bay fishery resources should be similar to those of the preferred alternative.

Impacts of Construction

The project components are discussed in Chapter 2. The impacts due to construction of the project are temporary and are discussed in this section. This section also discusses the various methods of construction, testing and monitoring, and mitigation measures. Table 5-33 summarizes the environmental impacts caused by construction.

The foundation materials on which the new levees and related structures are planned to be constructed, are mostly composed of organic soil with depths of peat varying from at least 10 feet in the north to approximately 20 feet in the south of both Staten and Tyler islands.

For project alternatives with dredging of channels without levee setback, the dredged materials will be placed on the back of the existing levees. Temporary settling areas may be needed for drying of the dredged materials before they can be used to reinforce a levee depending on the type of equipment used for the dredging. Dredging can be accomplished by the use of a barge-mounted clamshell or dragline.

In case of project alternatives involving enlargement of channels with levee setback, new channels and levees will be constructed on the land adjacent to the existing levee. Most of the excavated organic soil from the new channels will be utilized in building the riverside berms on each side of the channel.

The setback levee is designed to be constructed with borrow materials imported from other sources. To minimize impacts on the roadway traffic in the project area, imported materials (embankment and riprap) could be barged to the site. Where barging is not possible, imported materials will be hauled by trucks. Concrete can be batched near the project site on dry land.

Table 5-33. Summary of Environmental Impacts Caused by Construction

	Yes	Maybe	No
1. Earth. Will the proposal result in:			
a. Unstable earth conditions or in changes in geologic substructure?	—	—	X
b. Disruptions, displacements, compaction, or overcovering of the soil?	X	—	—
c. Changes in topography or ground surface relief features?	X	—	—
d. Destruction, covering, or modification of any unique geologic or physical feature?	—	—	X
e. Any increase in wind or water erosion of soil, either on or off the site?	—	X	—
f. Changes in deposition or erosion of beach sands, or changes in siltation, deposition or erosion that may modify the channel of a river or stream or the bed of the ocean or any bay, inlet, or lake?	—	—	X
g. Exposure of people or property to geologic hazards, such as earthquakes, landslides, mudslides, ground failure, or similar hazards?	—	—	X
2. Air. Will the proposal result in:			
a. Substantial air emissions or deterioration of ambient air quality?	—	—	X
b. The creation of objectionable odors?	—	—	X
c. Alteration of air movement, moisture, or temperature, or any change in climate, either locally or regionally?	—	—	X
3. Water. Will the proposal result in:			
a. Changes in currents, or the course or direction of water movements, in either marine or fresh water?	—	—	X
b. Changes in absorption rates, drainage patterns, or the rate and amount of surface water runoff?	—	—	X
c. Alterations to the course or flow of flood waters?	—	—	X
d. Change in the amount of surface water in any water body?	X	—	—
e. Discharge into surface waters, or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen, or turbidity?	X	—	—
f. Alteration of the direction or flow rate of ground water?	—	—	X
g. Change in the quantity of ground waters, either through direct additions or withdrawl, or through interception of an aquifer by cuts or excavations?	—	—	X
h. Substantial reduction in the amount of water otherwise available for public water supplies?	—	—	X
i. Exposure of people or property to water-related hazards such as flooding or tidal waves?	—	—	X
4. Plant Life. Will the proposal result in:			
a. Changes in the diversity of species, or number of any species of plants (including trees, shrubs, grass, crops, and aquatic plants)?	—	—	X
b. Reduction of the number of any unique, rare or endangered species of plants?	—	—	X
c. Introduction of new species of plants into an area, or barrier to the normal replenishment of existing species?	—	—	X
d. Reduction in acreage of any agricultural crop?	X	—	—
5. Animal Life? Will the proposal result in:			
a. Change in the diversity of species, or numbers of any animal species (birds, land animals, including reptiles, fish and shellfish, benthic organisms or insects)?	—	—	X
b. Reduction in the number of any unique, rare, or endangered species of animals?	—	—	X
c. Introduction of new species of animals into an area, a barrier to the migration or movement of animals?	—	—	X
d. Deterioration of existing fish or wildlife habitat?	—	—	X
6. Noise. Will the proposal result in:			
a. Increases in existing noise levels?	X	—	—
b. Exposure of people to severe noise levels?	—	—	X
7. Light & Glare. Will new light and glare occur?	—	—	X
8. Land Use. Will the proposal result in substantial alteration of the present or planned land use of an area?	X	—	—
9. Natural Resources. Will the proposal result in:			
a. Increase in rate of use of any natural resources?	—	—	X
b. Substantial depletion of any nonrenewable resource?	—	—	X
10. Risk of Upset. Will the proposal involve:			
a. Risk of explosion or release of hazardous substance (including but not limited to oil, pesticides, chemicals, or radiation) in the event of an accident or upset?	—	—	X
b. Possible interference with an emergency response plan or an emergency evacuation plan?	—	—	X
11. Population. Will the proposal alter the location, distribution, density, or growth rate of the human population of an area?	—	—	X
12. Housing. Will the proposal affect existing housing or create a demand for additional housing?	—	X	
13. Transportation/Circulation. Will the proposal:			
a. generate substantial additional vehicular movement?	—	—	X
b. affect existing parking facilities or demand for new parking?	—	—	X
c. Substantially impact existing transportation systems?	—	—	X
d. Alter present patterns of circulation or movement of people and/or goods?	—	—	X
e. Alter waterborne, rail, or air traffic?	—	—	X
f. Increase traffic hazards to motor vehicles, cyclists, or pedestrians?	—	—	X
14. Public Services. Will the proposal affect or result in a need for new or altered governmental services in these areas:			
a. Fire protection?	—	—	X
b. Police protection?	—	—	X
c. Schools?	—	—	X
d. Parks or other recreational facilities?	—	—	X
e. Maintenance of public facilities, including roads?	—	—	X
f. Other governmental services?	—	—	X
15. Energy. Will the proposal result in:			
a. Use of substantial amounts of fuel or energy?	—	—	X
b. Substantial increase in demand on existing sources of energy, or require development of new energy sources?	—	—	X
16. Utilities. Will the proposal result in a need for new systems or substantial alterations to the following utilities:			
a. Power or natural gas?	—	—	X
b. Communications systems?	—	—	X
c. Water?	—	—	X
d. Sewer or septic tanks?	—	—	X
e. Storm water damage?	—	—	X
f. Solid waste and disposal?	—	—	X
17. Human Health. Will the proposal result in:			
a. Creation of any health hazard or potential health hazard (excluding mental health)?	—	—	X
b. Exposure of people to potential health hazards?	—	—	X
18. Aesthetics. Will the proposal result in obstruction of any scenic vista or view open to the public, or will the proposal result in the creation of an aesthetically offensive site open to public view?	—	—	X
19. Recreation. Will the proposal affect the quality or quantity of existing recreational opportunities?	—	—	X
20. Cultural Resources. Will the proposal:			
a. result in alteration or destruction of a prehistoric or historic archeological site?	—	—	X
b. result in adverse physical or aesthetic effects to a pre- historic or historic building, structure, or object?	—	—	X
c. have the potential to cause a physical change that would affect unique ethnic cultural values?	—	—	X
d. restrict existing religious or sacred uses within the potential impact area?	—	—	X
21. Mandatory Findings of Significance.			
a. Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number of or restrict the range of a rare or endangered plant or animal, or eliminate important examples of the major periods of California history or prehistory?	—	—	X
b. Does the project have the potential to achieve short-term—to the disadvantage of long-term—environmental goals? (A short-term environmental impact is one that occurs in a relatively brief, definitive period, whereas long-term impacts will endure well into the future.)	—	—	X
c. Does the project have impacts that are individually limited but cumulatively considerable? (A project may impact two or more separate resources where the impact on each is relatively small but where the effect of the total impacts on the environment is significant.)	—	—	X
d. Does the project have environmental effects that will cause substantial adverse effects on human beings either directly or indirectly?	—	—	X

Table 5-34 Summary of Estimated Major Material Quantities Needed for Construction of North Delta Program Facilities

Item	Unit	Project Alternatives									
		2A	2B	3A	3B	4A	4B	5A	5B	6A	6B
Excavate Existing Channel	CY	3,527,000	3,527,000	6,548,000	6,548,000	15,569,000	15,569,000	10,831,000	10,831,000	2,937,000	2,937,000
Reinforce Existing Levee	CY	219,000	219,000	295,000	295,000	1,280,000	1,280,000	806,000	806,000	---	---
Excavate New Channel	CY	---	786,000	---	786,000	9,950,000	10,736,000	7,960,000	8,746,000	---	786,000
Berm Embankment using Channel Excavation	CY	---	---	---	---	2,980,000	2,980,000	1,811,000	1,811,000	---	---
Levee Embankment using Channel Excavation	CY	---	123,000	---	123,000	2,808,000	2,931,000	1,388,000	1,511,000	---	123,000
Levee Embankment using imported Borrow	CY	---	17,000	---	17,000	9,762,000	9,779,000	5,507,000	5,524,000	2,592,000	2,609,000
Riprap	TON	126,000	189,000	243,000	306,000	1,654,000	1,717,000	1,423,000	1,486,000	1,944,000	2,007,000
Bedding (6" under riprap)	TON	36,000	50,000	70,000	84,000	550,000	564,000	463,000	477,000	550,000	564,000
Geotextile	SF	1,117,000	1,533,000	2,156,000	2,572,000	31,855,000	32,271,000	27,861,000	28,277,000	13,496,000	13,912,000
Concrete-Structural	CY	---	16,000	---	16,000	10,000	26,000	10,000	26,000	39,300	55,300
Reinforcing Steel	LB	---	3,288,000	---	3,288,000	2,392,000	5,680,000	2,392,000	5,680,000	8,549,000	11,837,000
Structural Steel	LB	---	720,000	---	720,000	---	720,000	---	720,000	---	720,000
Structural Excavation	CY	---	123,000	---	123,000	---	123,000	---	123,000	17,000	140,000
Land Acquisition	AC	---	15	---	15	1,229	1,244	1,041	1,056	12,700	12,715
Alternative Costs (in $1,000) (NOT INCLUDING MITIGATION COSTS)		**$29,000**	**$59,000**	**$53,000**	**$83,000**	**$368,000**	**$398,000**	**$260,000**	**$290,000**	**$250,000**	**$280,000**

Preferred Alternative

Preliminary quantity estimates of earthwork and other major materials needed for construction are summarized in Table 5–34.

A common method of constructing an embankment where organic soil is encountered is to remove the organic material and replace it with a mineral soil. However, this method is not considered practical because of the high cost of the large volume of borrow materials needed to replace the equally large volume of cut. Instead, the borrow materials for construction of new levees, will be placed on the existing ground, with a construction fabric to provide separation from the peat soil below. However, because of the existence of peat ranging in depth from 10 to 20 feet in most of the project areas, it is anticipated that considerable settlement will occur during and after construction.

The estimated quantity of borrow for the embankment has been increased by up to a maximum of 50 percent, depending on the depth of peat to account for the expected settlement. Settlement can be as much as 50 percent of the depth of the organic materials in the foundation. About half of the total settlement is expected to occur quite rapidly, within two to three months; another fourth is expected within three years after placement; and the remainder over a long period of time.

Where organic materials are not uniformly deep, differential settlement could cause tension cracking within the levee and subject the levee to piping and subsequent failure. To minimize this problem, levee construction may include the use of geotextiles, cements, and special placement techniques. Also, to promote quick settlement and stabilization, foundations with deep organic materials can be provided with drainage facilities to release pore pressure. In order to prevent the occurrence of piping, levee design will ensure that the materials used are compatible. As a consequence of all these considerations, the construction will take longer and probably be more expensive than with conventional methods.

Channel Improvements — Physical Impacts

The main features of the North Delta Water Program include improvement of the channels either by dredging of the channels or enlargement with levee setbacks.

Water quality parameters, such as turbidity, heavy metal concentrations, and nutrient concentrations, will not be affected by the dredging. These parameters will be affected during the dredging operations, but the effects will be short-term and the water quality is expected to return to normal levels shortly after dredging is completed.

The dredging operations will have no long term effects on benthic organisms. Depending upon the extent of channel dredging, removal of benthic organisms will range from a small portion to almost all organisms. For near complete removal, studies have shown that the remaining organisms plus natural migration will quickly repopulate the channel. In areas of minor dredging, the existing benthic community would supply the organisms for repopulation. There will be a localized, temporary impact on fish dependent upon benthic organisms for food.

Dredged materials will be deposited on the land side of existing levees or on the water side of new levees to create water side berms. There will be a temporary increase in surface erosion due to rain and wind until a new vegetation cover can be established. After earth moving operations have been completed the bare areas will be re-seeded, and where necessary, erosion protection measures will be employed. The water side slopes of levees and berms will be protected with a layer of construction fabric covered by rip-rap to protect against wave and flow erosion.

The setback levees and new channel will be constructed with the existing levees in place, so the construction operations will have no immediate impact upon water quality in the channels. Upon completion of the setback levees and new channels, the new channels will be filled by pumping, siphoning, or controlled breaching to prevent excessive scour and turbidity. Breach excavation will be completed when water levels are equalized, using backhoe, clamshell, or dragline. This operation will result in temporary increases in turbidity, similar to dredging operations.

The physical features of the proposed work are summarized below:

Channel Dredging. The channels would be be increased in cross sectional areas to the extent possible by dredging the channel bottoms to an elevation of about 20 feet below mean sea level while maintaining a side slope no steeper than 2:1 on either side of the existing channel. Dredging can be accomplished by the use of barge-mounted clamshell, dragline, or hydraulic dredge. The materials to be excavated from the channel bottom will be placed on the land side of the existing levee. The excess dredged materials may also be used for creating island and water side berm construction. A typical section of channel dredging is shown on Figure 5–30.

Channel Enlargement with Levee Setback. This includes excavation of a new channel with a new setback levee in addition to dredging of the existing channel. The maximum depth of excavation will be limited to about 20 feet below mean sea level for both the existing and the new channels with water side slopes no steeper than 2:1. The exterior side slopes of the setback levee will vary from 3:1 to 5:1, depending on the depth of underlying peat in the foundation. In addition to the new setback levee, berms about 50 feet wide are planned for each side of the new channel to create additional wildlife habitat as shown on the typical section of channel enlargement in Figure 5-30. The size of the new channel is determined from the total cross-sectional area required to pass the 100 year flood flow safely.

No Action Alternative. The No Action Alternative is not expected to affect channel turbidity, benthic life, or erosion rates.

Preferred Alternative. The preferred alternative, 5B, involves extensive dredging, excavation, and new levee construction. The work will be done in phases, beginning with the South Fork Mokelumne River at its junction with the San Joaquin River a nd working upstream. Construction methods, turbidity control, erosion control, and management of contaminants will be in accordance with regulatory requirements to minimize construction impacts. Management of potential contaminants is described under "Channel Improvements - Biological Impacts.

Other Alternatives. Alternatives 4A, 4B, and 5A will have impacts similar to the preferred alternative. Alternatives 2A, 2B, 3A, and 3B involve dredging and/or Delta Cross Channel gate enlargement only. Potential physical impacts of dredging are described in previous paragraphs. Alternatives 6A and 6B require the construction of new setback levees along the South Fork Mokelumne River downstream from Georgiana Slough, construction of overflow structures on the north and south ends of Staten Island, and breaching the levees of Dead Horse Island and Mc Cormack-Williamson Tract. These construction activities will have temporary and localized impacts on turbidity at the time the exist ing levees are breached. The new levees will require revegetation to minimize surface erosion. No channels would be dredged under these alternatives.

Channel Improvements — Biological Impacts

Background. Most of the NDP alternatives include dredging and setback levees for channel enlargement and involve using the dredge material for constructing new levees, reinforcing existing levees, or enhancing habitat. Toxics in the dredge material may cause a variety of terrestrial and aquatic problems during and after construction. Dredging operations cause some degree of turbidity in the channels; this, in turn, may cause contaminants in the sediment to become waterborne, where they may pose a health risk to aquatic life and instream users. When anaerobic dredge material is exposed to air, it begins to oxidize and acidify, and its toxicity may increase. Rainfall can percolate through the dredge material, contaminating ground water, soil, and crops. Surface runoff from rainfall can also flow over the dredge material, carrying contaminants into ditches and adjacent channels. Even if contaminants are not transported by percolation and surface erosion, plants grown in the dredged material can accumulate certain toxic substances, thereby making them available to the food chain. Evaluation of potential toxicity concerns is an integral part of the permits process.

The Department filed for a Department of the Army permit (commonly referred to as a Section 404 permit) on March 10,1989. On the same date the Department requested that the Regional Water Quality Control Board, Central Valley Region (Regional Board) initiate the review process to evaluate impacts of the project on water quality, in accordance with Section 401 of the Clean Water Act (33 USC 1341).

Prior to approval of the Section 404 permit by the Corps, the Regional Board must provide certification, or a waiver of certification, that the proposed project will not violate state water quality standards.

The first step in the certification process is to determine whether any toxic materials are present in the channels that might be dredged.

Accordingly, in late 1989, a Dredge Material Testing Program was initiated to determine the composition and toxicity of channel bed material from potential dredge sites in the north Delta. Toxics are either man-made or naturally occurring substances that pose health risks directly or indirectly to human, terrestrial or aquatic life. Some of the toxics present in the north Delta may have been released by mining operations in the Sierra Nevada to the east and carried downstream to be deposited in the channel sediment. Some of the Delta toxics are derivatives of pesti-

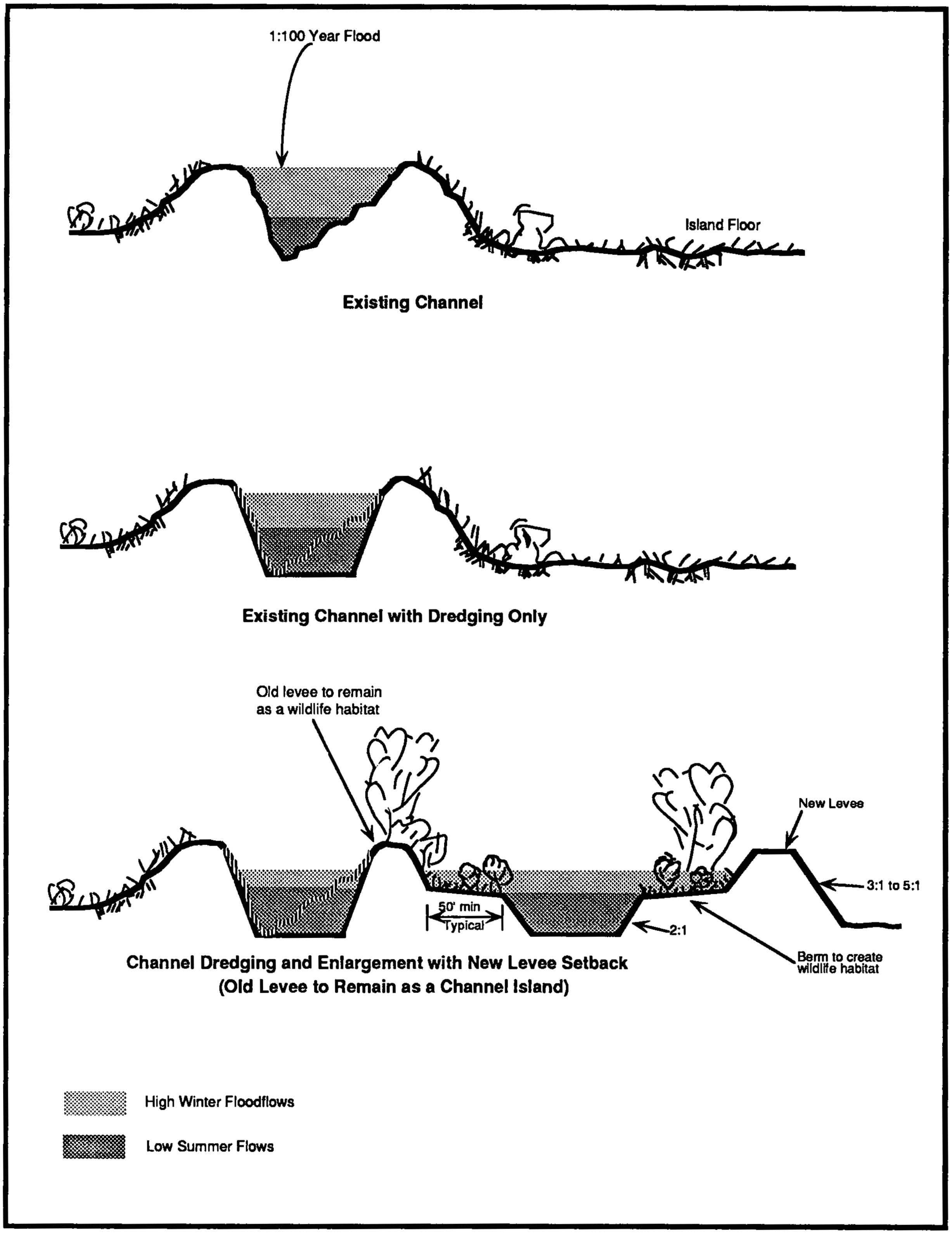


Figure 5-30. Possible Channel Capacity Improvements

cides used for agriculture. Residues from pesticides no longer in use may still be present. Marinas and boats are a source of Delta toxics such as copper and tributyltin (TBT). Presently, both federal and state regulations have curtailed the use of some of these harmful toxics, but not before these practices have deposited contaminants in some areas in the north Delta.

The first phase of the Dredge Material Testing Program involved preliminary testing of potential dredge sites for sediment-borne toxics. Six sites on the Mokelumne River system were selected on the basis of probable toxicity from low to high (Figure 5-31). Surface samples (about 6-inch depth) of dredge material were taken for analysis at each site. Samples were sent to private labs and analyzed according to EPA standards for processing and detection. Table 5-35 lists the test results for all six sites for the metal mercury and TBT. Appendix I shows the results of all other toxic chemicals and metals tested for.

A workshop was held by DWR on June 13, 1990 to evaluate and discuss the first phase test results. The Department of Fish and Game, Department of Health Services, State Water Resources Control Board, and Regional Board staffs attended the workshop. The participating agencies agreed that the greatest concerns involved elevated levels of mercury. However, many questions about sediment sampling and evaluation requirements were unresolved.

On July 20, 1990, a second meeting on dredge material testing was held with Dr. Richard Lee, Project Manager of the Corps Waterway Experiment Station (WES), as well as a SWRCB representative. WES, located in Vicksburg, Mississippi, has the facilities and expertise to perform all the major dredge material tests. Procedures for sampling, transporting, and evaluating the sediment in the study were discussed in detail. Concerns about mercury

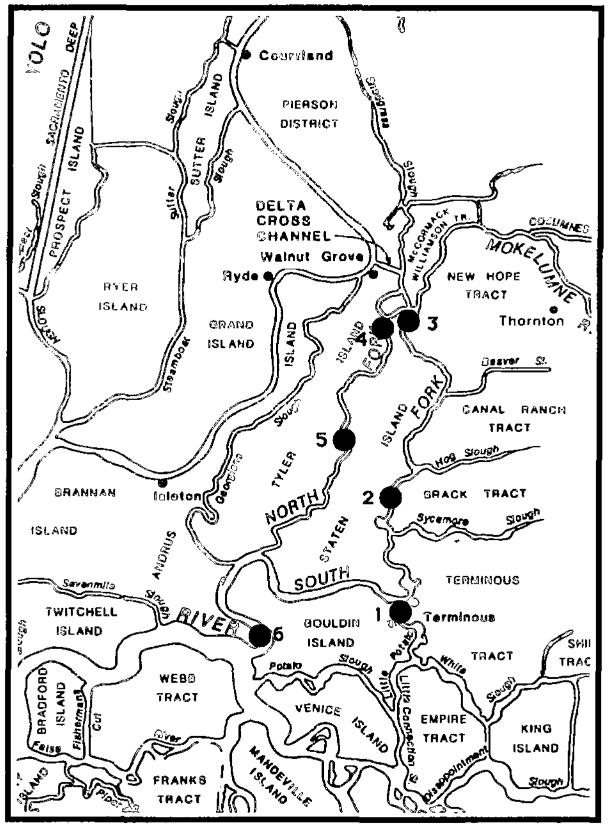


Figure 5-31. Dredge Material Test Sites

and tributyltin (TBT) were reiterated. These potential toxic contaminants are described as follows.

Mercury. The element mercury is an extremely dense metal that exists in a liquid state at standard temperature and pressure. Metallic mercury and organic mercury are relatively insoluble in water, whereas certain types of inorganic mercury are water soluble. Most of the soluble mercury in an estuary settles out of the water column and deposits in the channel sediment. Mercury is currently used in plastic manufacturing, agricultural chemicals, electrical component manufacturing, and dental sup-

Table 5-35
Preliminary Test Results for Mercury and Tributyltin

Toxic	Units	EPA Standard	Station 1	2	3	4	5	6
Mercury	mg/kg	20	0.14	0.46	37.0	7.6	34.0	30.0
Tributyltin	vg/kg	NE[1]	5.4	3.3	ND[2]	3.5	2.4	5.3

[1]EPA has not established standards for tributyltin.
[2]Not detected.

plies. Also, mercury was used extensively in Sierra Nevada mining operations to amalgamate gold.

Mercury can be formed into different compounds with methyl mercury as the most toxic because it is the most easily absorbed and most slowly lost by plant or animal tissues. Most plants will absorb mercury and translocate into different areas, such as leaves or roots. In birds, methyl mercury, found in contaminated plants or fish, accumulates in the liver-kidney area and can cause reproduction disorders and death. Predatory birds are especially susceptible to mercury poisoning because of the food chain magnification of the metal. Fish can accumulate extremely high quantities of mercury without showing any detrimental physical effects. In both animals and humans, mercury can cause health disorders and death if ingested in sufficient concentrations for a specific duration.

Preliminary test results for mercury (Table 5-35) show three stations three stations where reported sediment mercury concentrations were high, ranging from 30.0 to 37.0 mg/Kg. Under the Title 22 definition of a hazardous waste, mercury concentrations exceeding the Total Threshold Limit Concentration (TTLC) of 20 mg/KG could be defined as a hazardous waste. The samples did not exceed the soluble threshold limit concentrations (STLC) of 0.2 mg/L. The Department is currently resampling all sites to confirm the reported mercury concentrations.

Tributyltin (TBT). TBT, which contains the metal tin, has recently been identified as an environmental concern for both marine and aquatic life. TBT has been added to marine paint as an anti-fouling agent for over 20 years to prevent the buildup of barnacles and other invertebrates on shiphulls. Paint containing TBT can stay toxic for up to seven years.

In 1988, Congress passed bills restricting the use of TBT in anti-fouling boat paints. The Navy has stopped using TBTpaints except on aluminum hull boats. The California Department of Food and Agriculture currently restricts the use of TBT anti-fouling paints on any surface that may comein contact with water.

TBT's effect on humans and the environment is not fully known, partly due to the lack of research performed on TBT effects in fresh water environments. Until further study and analysis are completed, EPA will not establish drinking water standards for water-borne TBT.

Most of the TBT that is released into the water ends up in the channel sediment. TBT accumulates in concentrations ranging from one to four orders of magnitude greater in sediment than in the water column above it. TBT can be re-suspended in water if the sediment is agitated, as in dredging operations. Once in suspension, TBT remains in the water until it attaches itself to sediment particles and settles to the channel bed. In fresh water the half-life of TBT is about 238 days.

Most aquatic life metabolizes TBT at various rates in different tissues. Once it is ingested, the half-life of TBT also varies with the type of aquatic organisms but ranges from 7 to 60 days. In general, marine organisms are more sensitive to TBT than are aquatic organisms.

Table 5-35 shows that TBT is present in north Delta channel sediment, but no data are available for determining whether the concentrations are significant.

Dredge Material Testing Workplan. Based on the results of the preliminary sampling programs and the two dredge material testing meetings held in June and July, DWR is currently drafting a work plan to analyze the dredge material in the north Delta area. This work plan may include one or more of the following six dredge material tests to determine the potential impacts of dredging and placing channel sediments on the landside of delta levees: core sampling, in-situ, bioassay, effluent quality, surface runoff, and leachate quality tests. Bioassay, effluent, surface runoff, and leachate quality tests are all in-lab tests. These tests are described as follows:

The core sampling test involves extracting channel bed core samples and analyzing them to determine both engineering properties and concentrations of toxic contaminants. Core samples may be taken from depths up to 20 feet below mean sea level, which will probably be the dredging depth limit. Samples would be analyzed for toxics and contaminants to determine toxicity stratification in the channel bed. Three core samples per site would be taken.

The in-situ test involves placing about 1,000 cy of dredge material on land and allowing the material to weather under natural hydrologic conditions over a period of up to two years. The dredge material would be monitored to evaluate pH, decomposition characteristics, runoff water quality, and toxicity levels during the aging process as it would affect plant and animal life. Natural revegetation and wildlife re-establishment of the dredge material would also be monitored and evaluated. This test would serve as a check of the lab test results.

The bioassay test subjects three terrestrial and aquatic species to dredge material and its drainage water to determine their effects on growth rate, reproductivity, longevity, and bioaccumulation. In the plant bioassay test, plants are grown on the sediment under conditions simulating the proposed upland disposal environment and monitored throughout the test growth period. In the animal bioassay test, fish and mollusks are subjected to various concentrations of drainage water from oxidized dredge material and monitored to evaluate immediate and long-term effects.

The effluent test uses the water that is discharged as the sediment is placed on the land side of the levee during dredging. The effluent may contain levels of both dissolved and particulate contaminants. A modified elutriate test procedure, developed under the U.S.Army Corps of Engineers Long-Term Effects of Dredging Operations (LEDO) Research Program, can be used to predict both the dissolved and particulate-associated concentrations of contaminants.

The laboratory test simulates contaminants release under disposal conditions. The lab procedure involves mixing a certain ratio of sediment to water to approximate that expected under field conditions. The mixed slurry is then aerated for a period of time and allowed to settle. A sample of the supernatant water is then analyzed for total concentrations of contaminants of concern. Concentrations can be compared with applicable water quality standards after consideration of appropriate mixing zone and the quality of the receiving water.

The surface runoff test helps evaluate contaminant mobility in rainfall-induced surface runoff as part of the overall environmental impact of the dredged material. Physical and chemical changes occur when sediment is exposed to air. The effects of drying the sediment are considered in estimating the quality of the runoff.

A laboratory test using a rotating disk type rainfall simulator has been developed and is being used to predict surface runoff-water quality from dredged material as part of the Corps of Engineers/Environmental Protection Agency Field Verification Program. This test protocol involves taking a sediment sample from a waterway and placing it in a soil-bed lysimeter in its original wet, anaerobic state. The sediment is allowed to dry out. At intervals during the drying process, rainfall events are applied to the lysimeter, and surface runoff-water samples are collected and analyzed for selected water-quality parameters. The dredged material pH can decrease to less than 7 and sometimes to less than 4, particularly when high concentrations of sulfide and organic material are present.

The leachate test evaluates the potential for subsurface drainage water from dredge material placed in an upland environment from reaching adjacent aquifers or surfacebodies of water by leaching. The leaching potential analysis of dredged material is needed in order to evaluate potential migration of contaminants.

A sample of the sediment is dried for six months, and subsamples are taken for the leachate tests. The laboratory procedure for the kinetic leachate test includes combining sediment and distilled water in centrifuge tubes to maintaina certain established test ratio. The tubes are then shaken for several days and samples are taken periodically for analysis.

The sequential batch leach test utilizes a certain ratio of sediment to water added to a centrifuge tube. After shaking, the samples are centrifuged and the supernatant liquid is analyzed. This process is repeated for a period of time by replenishing water taken from the original tubes.

To date, there have been no obvious impacts of channel dredging on vegetation, fish, or wildlife, despite dredging for levee and channel maintenance over the past 100 years. However, construction impacts and more subtle long-term impacts of the proposed project need to be adequately investigated prior to project implementation. Accordingly, the Dredge Material Testing Workplan will incorporate all tests and procedures needed to address the concerns raised in the preliminary Dredge Material Testing Program.

No-action Alternative. Under the No-action alternative, dredging will not occur. Channel bed material will remain generally undisturbed except for localized dredging for levee maintenance and during floods.

Preferred Alternative. The preferred alternative includes dredging the existing channels of the major north Delta channels as shown in Figure 3-1. Approximately 11 million cubic yards will be dredged and used to strengthen existing levees, construct waterside berms, and construct new setback levees.

There are five marinas in the project area: Walnut Grove Marina on Snodgrass Slough, Wimpy's Marina at the junction of the North and South forks Mokelumne River, Tower Marina at the junction of South Fork Mokelumne River and Little Potato Slough, the marina complex at the junction of Georgiana Slough and the Mokelumne River, and the marina complex at the junction of the Mokelumne River and the San Joaquin River. Past and present operations at these marinas may have deposited contaminants in the channel bed, which may become available to the food chain during dredging operations. The numerous agricultural drainage return systems in the north Delta may also have deposited metals and other contaminants used in pesticides and herbicides.

Other Alternatives. All the other alternatives, except the flood by-pass alternatives, involve dredging to some degree. Dredge site locations are all adjacent to or downstream of marinas and agricultural drainage return pumps. Therefore, results from the dredge material analysis may affect the possible uses of the material or may negate the dredging option. Since the flood by-pass alternatives do not involve dredging, results from the dredge material testing program will not affect these alternatives.

Impacts due to Earthquake Loadings

All the north Delta project alternatives include either reinforcing of existing levees or construction of new levees or a combination of both. The design considerations for these reconstructed or new levees would include anticipated earthquake loadings.

A potential cause of levee failure in the Delta that has not been fully studied is liquefaction of the foundation due to earthquake. Liquefaction is a phenomenon whereby, during shaking from an earthquake, saturated sands lose strength and flow like a liquid. Liquefaction potential depends on ground acceleration, material types and relative density. Other factors which can influence liquefaction potential in the Delta include type and size of seismic waves generated, duration and amplitude of ground shaking, drainage conditions at a potential site, and degree of saturation or non-saturation of levee and foundation materials.

The new levees will be constructed with mineral soils that are stronger than the predominantly organic soil formation.

Apart from foundation failure, earthquake shaking also has the potential to cause slope failures.

The Loma Prieta earthquake of October 17, 1989, with a magnitude of 7.1 on the Richter scale, caused no apparent levee failure in the Delta which was approximately 60 miles from the epicenter. The seismograph at Clifton Court Forebay recorded a maximum ground acceleration of 0.08g for that earthquake.

However, information and reports from various sources indicate that there is significant risk of levee failure due to earthquake loads in the Delta. A preliminary seismic risk assessment of levees within the south Delta can be found in a study, *Preliminary Seismic Risk Analysis*, Bureau of Reclamation, February 1989, which suggests that up to 40 percent of the levees are susceptible to failure due to earthquake loads in the north Delta. The Corps completed a preliminary report on liquefaction in the Delta titled *Sacramento–San Joaquin Delta Liquefaction Potential* (Appendix J), U. S. Army Corps of Engineers, April, 1987 which also indicates the existence of failure potential due to an earthquake. Earthquake loadings will be considered in the project design.

Highway and Bridge Modification

DWR will work closely with the California Department of Transportation (CalTrans) regarding any possible impacts to State highways, and with county Departments of Public Works regarding impacts on county roads. All plans and activities affecting State highways will be coordinated with engineers from both the District 3 (Marysville) and District 10 (Stockton) offices of CalTrans.

No–action Alternative. For the No–action alternative, it is obvious that no highway or bridge modification would be required.

Preferred Alternative. For the preferred alternative 5B (Dredge the South Fork Mokelumne River and Enlarge the North Fork Mokelumne River and Enlarge the Delta Cross Channel Gates), two new bridges would be required, one on the Walnut–Grove–Thornton Road over the North Fork, and the other on State Highway 160 over the Delta cross channel. The existing bridge over the cross channel will be either extended or a new bridge on a new approach channel will be constructed depending on the location of the gate enlargement.

The project alternatives with only dredging of channels without levee setback will require practically no modification of the existing highways and bridges.

Other Alternatives. For all the other potential alternatives with levee setback and enlargement of the Delta cross channel gates, two new bridges will be required to replace the existing bridges which are not long enough to span the proposed enlarged channels. Of the two new bridges, one will be on the Walnut-Grove-Thornton Road over the South Fork, and the other on the State Highway 160 over the enlarged Delta cross channel as needed for the preferred alternative. Levee setbacks could also impact some roadway embankments and would require careful evaluation of alternative alignments.

Temporary Impacts of Construction

State Highway 160 could be impacted at several locations depending on the implementation of the alternatives. If river wells were to be constructed for mitigation between Hood and Courtland, possible highway relocation and reconstruction may be required. Some temporary inconveniences to local motorists are expected during earthwork operations for both dredging and levee setbacks.

Even though impacts to State highways can be minimized with some modification in construction planning, motorists may encounter detours and slight delays. This inconvenience will be handled in compliance with CalTrans regulations.

Construction of the project is expected to cause some short-term effects on the environment. The environmental control measures would be detailed in the special provisions of each contract document.

The relocation of structures, the possible modification of highways and bridges, and the use of county roads for hauling would cause some delays and inconveniences to local residents due to detours and rerouting of traffic in the affected areas. However, the contractor will be instructed to avoid peak traffic hours and weekends as much as possible and to have adequate signs and personnel to move traffic safely and expeditiously through construction zones.

Increased noise due to construction traffic and pile driving equipment at some sites would be unavoidable, but this effect would be localized and will have minor impacts on the public. The project area is not immediately adjacent to any metropolitan areas. These activities may have some effect on local wildlife. The contractor will have to meet the requirements of the California Occupational Safety and Health Administration (CALOSHA), which should preclude unacceptable noise level.

Since the project is in a rural area, dust would not become a serious problem during excavation and hauling. The contractor will be required to minimize the dust by watering or other means of control. The dust that cannot be controlled is not expected to exceed that caused by normal farming activities. The contract specifications may also require the contractor to apply appropriate dust-control measures on detours and operating roads.

Local water quality problems, such as increased turbidity, can be expected for a short time in some channels due to construction of bridge piers, cofferdams, and dredging. This impact will be extended through the construction period only, and will end once the project is operational. DWR will obtain permits from the Regional Water Quality Control Board, DFG, and the Corps for all operations that would increase turbidity.

During certain phases of construction, recreational activities on the north and south Mokelumne River, Delta Cross-Channel, and the area of Dead Horse Island will be inconvenienced. All necessary permits will be obtained from proper governmental authorities before construction can start.

Utilities, if any, such as gas and water supply lines, power and telephone cables, underground cables, and wells that would be disrupted by the project would be replaced or relocated at project expense. To minimize disruption of service, the relocation of such facilities would be handled by the utility company involved. Utility cables or pipelines in the project area will be either overhead or underground, as appropriate. Utility companies will be notified of construction in advance.

Wells within the right-of-way boundary would be either plugged and abandoned, replaced, or otherwise compensated for.

Where land acquisition is part of a project component, DWR and other involved agencies will assist each person, family, business, farm, or nonprofit organization to relocate or find an equivalent property. Every effort will be made to keep inconvenience to a minimum and to allow sufficient time for relocation. If necessary, a local office will be established for better service.

Impacts on fish migration from construction will be minimal. Cofferdams, built to divert water from bridge construction sites, will extend slightly into the river and may cause temporary increases in turbidity. The changed flow pattern from the cofferdams may temporarily impact fish migration, depending on timing and construction methods used.

Vegetation between the construction easement area of the canal embankment will be disturbed by construction equipment, resulting in the dislocation of wildlife. DWR has planned a mitigation program in compliance with HEP. As discussed under "Impacts on Wildlife and Wildlife Habitat," HEP was developed by DFG to evaluate the impacts of land and water development projects on the quantity and quality of wildlife habitat.

The USFWS will make certain that the Endangered Species Act of 1973 is fully administered. The act will ensure that the proposed project is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat for such species, unless an exemption of the project has been granted by the Endangered Species Committee established by the act. DFG will also ensure full protection of species on the State endangered list.

Impacts on SWP Service Areas

Improvements resulting from the NDP will beneficially affect the water quality and reliability of SWP supplies delivered to the SWP service areas. As a result, these improvements will have favorable socioeconomic impacts in the service areas, which could 1) include less disruption of water supplies and fewer shortages, and 2) provide less expensive source of water. In addition, the project will enable water users in the area to maintain their present quality of life. The project is not considered to be growth inducing.

Socioeconomic Impacts

Most of the impacts discussed above are difficult to quantify. However, the provision of less-expensive supplies can be measured by comparing the cost of the project with the cost of alternatives that would otherwise have to be implemented in the absence of the project. This analysis was presented in Chapter 3. The cost of options that would be displaced by the existence of the proposed facilities and the expected economic losses that would be avoided with the proposed facilities were analyzed. The total annual economic impact was estimated to be a benefit of about 49.6 million, with 41.2 million in the South Coastal service area alone.

Growth-Inducing Impacts

This section discusses the socioeconomic growth in the SWP service areas and areas affected by flood control. The location, timing, and magnitude of economic and population growth within a region are determined by a multitude of interrelated economic, social, and political factors, including:

- employment opportunities;
- availability and cost of natural resources, including land, water, and energy;
- availability and cost of housing;
- adequacy of community infrastructure (transportation facilities, fire and police protection, schools, recreational facilities, etc.);
- local government policy concerning growth issues (zoning ordinances, general plans, etc.); and
- participation in the National Flood Insurance Program.

Since each of those variables influences growth, it is very difficult to ascertain if a change in one of them is sufficient to cause a significant change in community growth rates.

DWR's planning activities are designed to accommodate existing and planned growth—not control it. The provision of water or a degree of flood control, by itself, is not considered as stimulating growth if all the other factors listed above are not conducive to that growth.

Several complex factors must be examined to determine growth inducement. First, are there alternatives (both demand management and supply augmentation) that could be implemented in the absence of the project? If alternatives are available (even if they are more expensive than the proposed project), it can be assumed that they would be implemented in the absence of the project. Hence, with or without the project, growth will occur; the only effect of the project is a less expensive source of water.

Another factor that needs to be considered is local government policy regarding growth. Most communities in the State have implemented land use policies through their general plans and zoning ordinances that attempt to manage growth in conjunction with their available resources. These plans address population growth, land use, circulation, public services, and environmental resources. The strength of these plans in managing growth varies from community to community.

The determination of whether a particular water project induces growth also depends on how it is used. For example, if the project's yield is used in addition to current surface and ground water supplies, then the resulting growth–inducing impacts could be different than if the yield were used to replace existing supplies (such as overdrafted ground water basins). Also, because many existing supplies in the Southern California service area will be reduced in the future (due to decreased Colorado River entitlements resulting from increased diversions to the Central Arizona Project and the lower Colorado River Indian tribes, as well as reductions in Owens Valley supplies), supplies from the proposed project are necessary merely to maintain current water supplies.

The NDP will not by itself meet the requirements of the National Flood Insurance Program. This program requires participating local governments to regulate flood plain development in their communities. Entry into the program is voluntary, but local regulations and ordinances must meet NFIP requirements before private property owners may participate in the insurance program.

Without LBG and KWB, The NDP will provide about 139 TAF of yield to the SWP per year. If it is assumed that this water would be distributed to the SWP service areas in proportion to the service areas' total entitlement, the distribution would be as follows:

Area	Acre–feet
North Bay	2,200
South Bay	6,300
Central Coastal	2,300
San Joaquin Valley	45,100
Southern California	83,100
Total	**139,000**

The Feather River service area is excluded because, as an area of origin, it will receive its full entitlement, with or without the proposed project. The Central Coastal entitlement assumes construction of the Coastal Aqueduct. In the San Joaquin service area, about *88* percent of the entitlement will be used for agriculture, leaving a remainder of about 5,400 AF for urban uses.

For the Southern California service area, the additional supplies provided by this project should not be considered as "new." In this service area, current entitlements to the Colorado River will be reduced 775,000 AF by year 2000 because of 1) increased diversions to the Central Arizona Project, and 2) increased water rights awarded to the lower Colorado River Indian tribes. In addition, a recent Superior Court ruling mandating drastic cuts in diversions from the Owens Valley into this service area may also cause a reduction of up to 60,000 AF from the current water supplies, bringing the total possible reduction to 835,000 AF. Thus, the 83,100 AF allotment that would go to Southern California would be required to partially offset this loss of supplies.

Although population growth is not directly related to water supplies, the relationship between the two can be estimated. For example, if estimates of the population supported by the project's supplies can be derived on the basis of the physical relationship between water supply and per–capita use, the above deliveries could physically support the following population:

Area	Population
North Bay	11,000
South Bay	31,500
Central Coastal	11,500
San Joaquin Valley	15,700
Southern California	0
Total	**69,700**

Because deliveries to the Southern California service area are needed to partially offset future losses of water supplies, they would not be considered as supporting "new" population.

Underlying this approach are a number of assumptions. First, it must be assumed that water supply from the project is the only constraint to growth, and that without the project, growth would not occur. This implies that there are no alternatives that could be implemented in the absence of the project. Also assumed is that all other resources (such as land and energy) and community infrastructure (roads, schools, police and fire protection, etc.) are adequate to accommodate growth.

These assumptions seem tenuous. The assumption that growth would not have occurred without the project may not be reasonable because there may be alternatives, such as waste water reclamation and desalination, that could be implemented in the project's absence. These alternatives may be very expensive, but they may be available. Also, even if the project's supplies are delivered, other resource constraints in the service areas may limit population growth. Examples include air and waste–water quality standards, traffic congestion, local government, and fiscal constraints. Given these limitations, this scenario does not provide a reasonable estimate of growth–inducing impacts. However, these numbers are provided for reference only and could be viewed as the estimated maximum growth.

A proposed water supply project should be considered to be growth-inducing only if it results in an increase in population projections compared with what would have occurred without the project. However, if population projections can be expected to remain the same with the project, the project can not be considered to be growth inducing.

A test of whether a project will be growth inducing depends on the availability and cost of alternatives that could be implemented in the absence of the project. If feasible alternatives are available, it must be assumed that they would be implemented in the absence of the project; thus, population growth will remain unchanged with or without the project. However, if feasible alternatives are not available, then the project would in fact remove a barrier to growth, thereby allowing it to occur.

Alternatives are available in all of the service areas. Some of these alternatives may be very expensive (such as desalination in coastal areas), but they are available. Because they are available, it can be assumed that population growth would continue with or without the project; hence no growth-inducing impacts would occur. This approach provides an estimate of minimum growth. The actual growth inducing impact may lie somewhere in between the two estimates.

The economic impact assessment follows a similar procedure; that is, it assumes that alternatives are usually available to meet projected population and economic growth, and that if the proposed project is not built, then alternatives (demand management and/or supply augmentation) will be implemented. If these alternatives are more expensive than the proposed project, the impact of the project is the avoidance of these higher costs (see Chapter 3).

Impacts on Central Valley Project Service Areas

The Central Valley Project service areas are discussed in Chapter 4, "Environmental Setting."

Relationship of the Proposed Action to Land Use Plans

The NDP would be coordinated with land use plans in the six Delta counties: Solano, Sacramento, San Joaquin, Yolo, Contra Costa, and Alameda.

The Council on Environmental Quality and the Farmland Protection Act of 1981 require federal agencies to assess, in their EIS's, the impacts of their actions on prime or unique farmland and to consider alternative actions that could lessen those impacts. As negotiations for the SDWMP near completion, this analysis will be accomplished. The Soil Conservation Service will be contacted to identify whether the proposed action or alternatives would impact any lands classified as prime and unique farmland.

Energy and Capacity Impacts

The impacts of NDP on energy and capacity; total generation of a plant in a given period; and maximum output from the plant at any given time were reviewed in recognition of the following:

- The points of analysis for energy conservation set forth in Appendix F of the California Environmental Quality Act guidelines.
- DWR's long-range energy resources and mitigation program.
- Operation studies and economic analysis (see Chapter 3, "Physical and Operational Comparison of Alternative" and "Economic Analysis").

To the extent that water deliveries through SWP facilities will increase due to the implementation of a NDP, SWP energy requirements will also increase. However, inefficient, wasteful, or unnecessary energy consumption will be avoided by measures such as water conservation, energy recovery along the system, cost effective improvement in machinery, and minimal use of on-peak energy. Such measures are included in DWR's energy program and were incorporated in the economic analysis, which also considered the high costs of energy and capacity.

The estimated average annual increase in energy requirements, assuming 3.8 MAF SWP demands, implementation of SDWMP, and construction of LBG and KWB, is about 1,170 gigaWatt hours (GWh) in SWP pumping load. About 290 GWh of this would be recovered by SWP recovery generation on the aqueduct. The remaining 880 GWh would be an increment to SWP system power require-

Table 5-36
Potential Impacts of Energy Resources

	Conventional Oil	Conventional Coal	Nuclear[1]
Land use for power plants			
(acres)	25-100	100-200	300-500
Cooling water required[1,2]			
(acre-feet)	1,380	1,380	2,330
Air emissions[3]			
(tons/year)			
nitrus oxide	1,880	2,070	—
sulphur dioxide	4,210	11,290	
particulates	143	18,434	
hydrogen sulfide	—	—	

[1]The larger land area (500 acres) is required if evaporation ponds are used for blowdown.

[2]For evaporative cooling towers.

[3]Annually.

ments. These figures are based on an increase of 550,000 AF in pumping at the Banks Pumping Plant on average. The 880 GWh is approximately equivalent to the annual energy that would be used by 95,300 homes, or the annual output of a 145-megawatt (MW) base load power plant operating at 68 percent of its maximum output rate. A base load plant is one that is intended to run almost continuously. *Examples of such* plants are Pacific Gas and Electric Company's Diablo Canyon nuclear plant on the central coast or Portland General Electric Company's Boardman coal plant in Oregon.

The specific source of 880 GWh cannot be determined at this time; it could come from any combination of existing power resources to which DWR has access; with interconnections, these could number in the hundreds. DWR does not plan to develop any new resources to meet this increase in project load. However, DWR anticipates future purchases of 100-MW blocks of unspecified baseload. For purposes of cost analysis, these purchases can be represented as shares in existing or future power plants. The potential impacts of 100 MW share of some typical energy resources are shown in Table 5-36.

A generic coal plant would probably be similar to the existing Reid Gardner coal plant in Nevada, in which DWR is a participant.

Mitigation measures used in constructing and operating a typical coal plant include:

- a sulfur dioxide scrubber to remove at least 85 percent of the sulfur dioxide in the flue gas,
- an electrostatic precipitator to remove virtually all fly ash from the flue gas,
- boiler design to limit nitrous oxide emissions to a maximum of 0.6 lbs/1,000,000 BTU, and
- dust abatement provisions for the coal handling and storage system.

Overall mitigation for increased power requirements is incorporated into: (1) environmental impact reports and design features for specific water and power facilities, (2) coordination of power sources and uses between utilities, (3) efficient use of water supplies, and (4) best use of off-peak power supplies to delay construction of new generating facilities.

Impacts on Navigation and Recreation

Various components in the NDP will have some affect on navigation and recreation. The benefits and possible impacts are discussed in this section.

Navigation

Delta channels support growing commercial and recreational traffic. About 5 million tons of cargo are handled annually by inland ports that serve ships coming up deep water channels from San Francisco Bay. Popularity for recreation is indicated by about 10,000 berths and over 100,000 pleasure boat registrations in five Delta counties.

Most Delta waterways are navigable by small craft, and the Sacramento River is maintained by the Corps as navigable for 145 miles between Suisun Bay and Colusa under the Sacramento River Shallow Draft Channel Project. Depths of 10 feet are provided below Sacramento, 6 feet from Sacramento to Colusa, and 5 feet from Colusa to Chico Landing. Also, the authorizing document for Shasta Dam provides for minimum releases of 5,000 cfs to maintain navigation depths; however, releases for other CVP purposes generally exceed this minimum requirement

In addition, the Corps maintains two deep water channels connecting Stockton and Sacramento with the Pacific Ocean. These channels will accommodate ocean-going shipping and are known as the Baldwin Deep Water Channel and the Sacramento Deep Water Channel respectively.

The NDP will have negligible effect on either the Stockton or Sacramento deep water channels and therefore, will not impact most of the commercial navigation. There is, however, a potential for impacting irregular navigation such as equipment and material barges for construction and repair and floating dredges.

Some channels in the north Delta are silted in, with exposed shoals, mud flats, and submerged debris. This restricts recreational use and can cause hazards for boaters in the area. Impacts on recreational use is discussed in greater detail in the following section. The NDP has the potential to significantly improve recreational boating.

Impacts from construction of the NDP are either temporary or negligible. These are discussed earlier in this chapter under Impacts of Construction.

The benefits and possible impacts are summarized below.

Benefits:

- Recreational water depths are increased in some upstream area.
- Additional shoreline will be created.
- Potential for separation of high speed and low speed traffic on channels with setback levees.

Impacts

- Temporary closing of certain reaches of channels and rerouting due to construction.
- Increased water flows may create a need for better navigational skills and awareness by recreational boaters .

Recreation

The NDP can provide for increased recreational opportunities in the Delta. Increased channel and land access through levee setbacks will add to the areas available for boating, fishing, and boater destination sites.

The Delta provides a variety of public recreational opportunities including fishing and motor boating (see discussion in Chapter 4, "Environmental Setting"). The report, Recreation Facilities Plan for North and South Delta, March 1988 estimates that without additional facilities, recreation days in the Delta are expected to reach 14.1 million by the year 2000.

However, the report also states that public recreational opportunities in the north Delta are limited because of insufficient facilities. Such public facilities as parking, boat launch ramps, camp units, and picnic areas ar e very limited in the north Delta, causing the demand for public recreation in the north Delta to far exceed the supply.

Water-related Delta activities depend on adequate water levels in the Delta channels; however, Delta water levels tend to be fairly consistent from year to year. During the drought of 1976-1977, while reservoirs throughout the State were extremely low, the Delta maintained about the same water levels and recreational opportunities as in other years.

The levee setback feature of the NDP offers a good opportunity for improving access to the North Delta. Public access to land and water is limited, because most land, including the levees, is privately owned. The present road system provides inadequate access for land-based recreation. Very few roads exist in the interior of the Delta. Parking along public roads is extremely limited. Recreationists often trespass on private property causing vandalism and damage to levees. Both the old levee and new levee constructed for the setback can be available for recreational opportunities. Specific recreation areas will be chosen with consideration for protecting wildlife and adjacent private lands.

Recreation on the new and existing levees will be designed for low impact uses. The wetland and riparian habitats that will be created and enhanced by the NDP can co-exist with limited uses such as hiking, bird watching, photography and fishing. The Nature Conservancy, a private nonprofit organization committed to wildlife preservation, has successfully used the concept of low intensity visitor use in many of their wildlife areas. Parking areas will be constructed to accommodate recreationists.

The NDP may impact recreational opportunities in Oroville Reservoir. Since SWP exports vary under the No-action alternative and other alternatives, including the preferred alternative, the operation of Oroville and San Luis reservoirs changes. This variation in reservoir operation will be reflected in changes in water surface elevations and the subsequent changes in recreational opportunities. Recreation use in these reservoirs is directly related to water levels, boating being one of the most popular activities. In 1987, Oroville Reservoir had over 800,000 recreation days of use, while San Luis Reservoir had almost 3,500,000 recreation days of use.

There are two marinas and four boat ramps at Oroville Reservoir and two boat ramps at San Luis reservoir. The water surface elevation required for these facilities to be usable and the frequency at which they could be used from June through September under the No-action, the preferred, and the other alternatives is shown in Table 5-37. The table indicates that recreational opportunities at San Luis reservoir will be unaffected, but those at Oroville Reservoir for the preferred alternative and the other alternatives will increase.

No-action Alternative. Under the No-action alternative, recreational opportunities in the north Delta will remain sharply limited. Demand for recreation in the Delta, currently exceeding supply, will continue to increase as the population of the Delta area grows.

The boat ramps at San Luis Reservoir will continue to be usable in almost all years. The boat ramps at Oroville Reservoir at Bidwell Canyon, Lime Saddle, Loafer Creek, and the spillway will be usable approximately 73, 75, 7 5, and 89 percent of the time respectively, during June through September. The marinas at Bidwell Canyon and Lime Saddle will be usable respectively some 73 and 75 percent of the time.

Preferred Alternative. Under the preferred alternative, recreational opportunities in the north Delta will increase. The levee setback feature will allow greater legal access to both land and water-based activities.

Under the preferred alternative, boating access at San Luis Reservoir will be unaffected since the boat ramps should remain accessible in virtually all years. At Oroville Reservoir, however, access to the boat ramps will be increased. Assuming no south Delta improvements are constructed, the boat ramps at Bidwell Canyon, Lime Saddle, Loafer Creek, and the spillway will be accessible some 81, 83, 83, and 90 percent of the time respectively, during June through September.

The marinas at Bidwell Canyon and Lime Saddle will be accessible about 81 and 83 percent of the time. Access improves if south Delta facilities are also constructed because spring and summer reservoir withdrawals from Lake Oroville will be reduced.

Alternatives 6A and 6B, which involve creation of a floodway through McCormack-Williamson Tract, Dead Horse Island, Staten Island, and portions of Bouldin and Brannan-Andrus Islands, would increase available water surface area by more than 10,000 acres. This would increase boating opportunities. Concurrently, the inundation of low-lying lands on these islands would reduce excellent wildlife habitat and low-impact recreation opportunities, such as bird watching, photography, and hunting.

Other Alternatives. All the other alternatives will have recreational impacts on Oroville and San Luis reservoirs similar to those for the preferred alternative. Those alternatives with dredging only, will slightly improve Delta recreational opportunities. Alternatives with setback levees will have recreational impacts similar to those for the preferred alternative.

Other Considerations

The analysis of environmental impacts in this chapter used statewide operation studies and Delta studies. If storage south of the Delta should increase with no assumption of Delta facilities beyond those in the various alternatives, the statewide operation studies and Delta studies would yield results similar to those completed. It is expected that the analyses of environmental impacts would yield results close to those discussed in this chapter. If additional storage south of the Delta were assumed, operational considerations to protect fish could be implemented to provide additional benefits for fish. If LBG and KWB are not constructed, the NDP could still provide additional operational flexibility for SWP diversions that could be used to benefit Delta fisheries. However, this benefit would be less than that resulting from construction of KWB and LBG.

Table 5-37
Impact of Alternatives on Boating in Lake Oroville and San Luis Reservoir
(Based on 57-Year Study with 3.8 MAF SWP Demands)

Facility	Required Water Level (ft)	Percentage of Time Facilities Usable (June—Sept) for alternatives										
		1	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B
Oroville Reservoir												
Boat Ramps												
Bidwell Canyon	781	73	78	81	80	81	80	81	80	81	80	81
Lime Saddle	775	75	80	83	82	83	82	83	82	83	83	83
Loafer Creek	775	75	80	83	82	83	82	83	82	83	83	83
Spillway	725	89	89	90	90	90	90	90	90	90	90	90
Marinas												
Bidwell Canyon	781	73	78	81	80	81	80	81	80	81	80	81
Lime Saddle	775	75	80	83	82	83	82	83	82	83	83	83
San Luis Reservoir												
Boat Ramps												
Dinosaur	325	100	100	100	100	100	100	100	100	100	100	100
Basalt	350	100	100	100	100	100	100	100	100	100	100	100

The statewide operation studies and Delta studies used in the analysis of environmental impacts in this chapter assumed SWP demands of 3.8 MAF. As SWP demands increase with time, without mitigation, the NDP, along with LBG and KWB, could gradually reduce the fishery benefits that will be gained through implementing the NDP.

Summary of Impacts Under the Preferred Alternative

Energy Impacts. To the extent that the SWP system's delivery capability will increase by implementing the NDP, the energy requirements will also increase. Average annual increase in energy required to pump the additional deliveries is estimated to be about 1,170 gigaWatt hours (GWh). Approximately 290 GWh of this will be recovered through the SWP power generation facilities, resulting in a net increase of 280 GWh.

Impacts During Construction. The preferred alternative involves channel enlargement of the main stem and North Fork Mokelumne River and dredging of the North and South Forks of the Mokelumne River. Disturbing the streambed may adversely impact the water quality in the short-term by causing any contaminants that may be present to become waterborne and pose health risks to aquatic life and instream users. Accordingly, in late 1989, a Dredge Material Testing Program was initiated to determine the composition and toxicity of channel bed material. The second phase of this program is still in progress. Other short-term impacts due to construction activities are as follows:

- increased traffic in the project area;
- increased noise levels;
- disturbed vegetation in the project area;
- possible disrupted local utilities; and
- increased dust and turbidity in the project area.

Impacts on Wildlife and Wildlife Habitat. Under the preferred alternative, levee setbacks are proposed along the main stem and the North Fork Mokelumne River. As a result, it is estimated that more than 350 acres of berm island habitat will be created. In addition, the South Fork Mokelumne River, will be dredged and it is proposed to utilize the dredged material to enhance wildlife habitat along the stream banks. Dredging activities will be staged to minimize any adverse impact on Sacramento Splittail spawning. The proposed project is expected to result in a net gain in wildlife habitat.

Impacts on Salmon and Steelhead. Under the preferred alternative, changes in Sacramento River flow and SWP exports may have some adverse impacts on migrating salmonids. Increased Feather River flows in the spring and early summer will improve conditions for egg incubation, rearing and out migration. Channel enlargement and levee setbacks will improve habitat and partially offset the effects of Delta Cross Channel diversions for migrating salmonids. Direct impacts of the changes in the conditions of the Delta on salmon are estimated by a fish loss model. The results of the model run with the preferred alternative indicated slightly greater losses of chinook salmon as compared to the no-action alternative.

Impacts on Striped Bass. The Sacramento River population of striped bass may be adversely impacted by the greater diversions of the flow through the Delta Cross Channel. However, reduction or elimination of reverse flow conditions in the lower San Joaquin River would have beneficial effects by directing more fish towards the Suisun Bay and away from Clifton Court Forebay. Proposed flexibility in the operation of the Delta Cross Channel under the preferred alternative may allow closing the gates during the times of peak egg and larvae production. Improvement of habitat and water quality for spawning and rearing in the south Delta, particularly the lower San Joaquin River should have positive effects on the striped bass population.

Impacts on Resident Fish. Direct impacts of the preferred alternative on resident game and non-game fish were evaluated. Increases in entrainment for resident fish were projected, but reductions in reverse flows should partly compensate or offset the estimated losses. Enhancement of riparian habitat and channel island with emergent vegetation in the North Fork Mokelumne River will increase the habitat for food and cover for many resident fish species.

Impacts Evaluated with Insufficient Information to Determine Significance

Impacts on San Francisco Bay. The impacts of pulse flows and total Delta outflow on the Bay estuary system are not completely understood. Overall, the preferred alternative will have minimal impact on the outflow pulse characteristics. Monthly Delta outflow under the preferred alternative will be reduced by an average of about four percent in the below-normal, dry, and critical years. The reduction of monthly outflow in the July through August period of these years will be about 12 percent. How Delta outflows under the preferred alternative affect San Francisco Bay biological resources is unknown.

Impacts on Archaeological and Cultural Resources

There are many archaeological sites within the legal Delta. Many exist in agricultural areas where it is considered impracticable to avoid a site when conducting farming operations. Archaeological sites are characterized as mounds of soil on natural levees containing a variety of artifacts, including unbaked clay shards, fresh water fish bones, stone chips, and human burials. The channelization of the Delta waterways, the extensive levee system, and intensive agricultural practices disturbed many areas before any archaeological surveys could be conducted.

Archaeological and cultural resource information centers at California State University, Sacramento, and California State University, Sonoma, were contacted for the Sacramento and San Joaquin counties portions of the project.

A record search has revealed six previously recorded prehistoric sites within 1/2 mile of the project. Only one prehistoric site appears to be within the possible impact area of the proposed levee and/or channel work. No previously recorded historic archaeological sites are known for the project area or the surrounding vicinity.

A limited archaeological study was conducted on December 5, 1989, of a portion of the New Hope Tract levee by a group from California State University, Sonoma. The group made an intensive field survey of a strip of land lying along the south levee of the Mokelumne River for about 5.4 miles. Discovery included several buildings within the western portion of the strip; they include a modern residence, three historic barns, and a collapsed historic residence with other features comprising a historic homestead complex. No additional historic-period resources were identified by this survey. There is the possibility, however, of the existence of subsurface stone or adobe foundations or walls, or other structural remains and backfilled wells and privies and other subsurface refuse deposits throughout the project area. There is also the possibility of subsurface prehistoric cultural resources within the project area. Such prehistoric materials include but are not limited to chert and obsidian flakes or artifacts; milling equipment such as mortars and pestles; locally darkened soils (midden), often containing artifacts and bone dietary debris; and human burials. Construction contract documents will specify that if concentrations of prehistoric or historic materials are encountered during construction, work in the immediate vicinity of the find shall halt until a qualified archaeologist has evaluated the situation. If human remains are encountered, the county coroner will be contacted.

The design and/or specifications of the alternative actions will include avoidance of known archaeological and cultural resources sites.

Sites that cannot be avoided will be evaluated for their significance and eligibility for listing in the National Register of Historic Places, pursuant to Section 106 of the National Historic Preservation Act. If it is determined that adverse effects will occur to sites which meet the criteria of the National Register, the State Historic Preservation Officer will be consulted so that acceptable mitigation procedures can be developed.

Irreversible or Irretrievable Commitments of Resources

A substantial irreversible and irretrievable commitment of resources will be involved in the construction of the NDP. Depending on the alternative selected, irretrievable large capital costs will be involved. Land will be purchased and its use changed from agriculture to either water conveyance or wildlife habitat. Large quantities of construction materials (Table 3-2 and Appendix H) will be used for erosion protection and levee construction. The Delta Cross Channel gate structure may be enlarged, requiring concrete, steel, and other construction materials. Large quantities of fossil fuels will be expended during the construction process, primarily for earth moving operations.

Operation of the SWP will probably be modified to take advantage of the hydrodynamic improvements the NDP will provide. These operational modifications are not irreversible and can be changed to simulate pre-NDP conditions if it is in the public interest. Although physical modifications to the Delta Cross Channel gates are irreversible, the gate operation can be modified to incorporate changes in policies.

Relationship Between Short-Term Uses of the Environment and Long-Term Productivity

Land use changes associated with Alternatives 2A,2B,3A, and 3B will be minor. Alternatives 4A,4B,5A, and 5B require the conversion of agricultural land to levees, berms, or channels, with a net improvement in wildlife and aquatic habitat. Water side berms and channel islands created with these alternatives will create several hundred acres of prime riparian, wetland, and upland habitat.

Alternatives 6A and 6B will permanently inundate and take out of production over 10,000 acres of agricultural land, creating primarily open water habitat. The existing Staten Island levees would remain, except where they would be breached at the north and south ends of the island. According to FWS, open water habitat is already plentiful in the Delta and the island flooding would result in a net loss for wildlife habitat. Thus these alternatives would result in a long term loss of agricultural productivity and wildlife habitat.

The NDP alternatives can increase long-term economic productivity by using developed water more efficiently. Facilities proposed by the NDP will allow more water diversions to meet the State's rapidly growing water requirements. The increased water diversions will help reduce ground water overdraft and contamination problems during dry years. The NDP will allow more water to be stored upstream of the Delta which will increase the productivity of the SWP by increasing hydropower generation capacity and flexibility. It will increase the SWP reliability, with long term improvements in the State's productivity.

Secondary Impacts of the Preferred Alternative

The California Environmental Quality Act requires consideration of indirect (secondary) consequences, which are related more to effects of the primary consequences than to the project itself and may be several steps removed from the project in a chain of cause and effect. Table 5-38 is a summary check list of the secondary impacts of the preferred alternative. The table includes topics assessed in this chapter as primary impacts. These are designated by a "p" notation and have been explained in detail. Parameters for which potential impacts are identified are briefly explained below:

Population. The proposed project cannot independently affect population characteristics of any region in the State or nation. As discussed under "Growth-Inducing Impacts," there are several other factors that play a significant role in determining the population characteristics in the future.

Housing. Future housing conditions are a function of several complex and interrelated factors, including the price

Table 5-38. Summary of Secondary Environmental Impacts

	Yes	Maybe	No
1. Earth. Will the proposal result in:			
a. Unstable earth conditions or in changes in geologic substructure?	_	_	X
b. Disruptions, displacements, compaction, or overcovering of the soil?		_	_
c. Changes in topography or ground surface relief features?		_	x_
d. Destruction, covering, or modification of any unique geologic or physical feature?	_	_	X
e. Any increase in wind or water erosion of soil, either on or off the site?	_		x_
f. Changes in deposition or erosion of beach sands, or changes in siltation, deposition or erosion that may modify the channel of a river or stream or the bed of the ocean or any bay, inlet, or lake?	_	_	X
g. Exposure of people or property to geologic hazards, such as earthquakes, landslides, mudslides, ground failure, or similar hazards?	_	_	X
2. Air. Will the proposal result in:			
a. Substantial air emissions or deterioration of ambient air quality?	_	_	X
b. The creation of objectionable odors?	_	_	X
c. Alteration of air movement, moisture, or temperature, or any change in climate, either locally or regionally?	_	_	X
3. Water. Will the proposal result in:			
a. Changes in currents, or the course or direction of water movements, in either marine or fresh water?	P_	_	
b. Changes in absorption rates, drainage patterns, or the rate and amount of surface water runoff?	P_	_	
c. Alterations to the course or flow of flood waters?	P_	_	
d. Change in the amount of surface water in any water body?	P	_	_
e. Discharge into surface waters, or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen, or turbidity?		_	X
f. Alteration of the direction or flow rate of ground water?	_	_	X
g. Change in the quantity of ground waters, either through direct additions or withdrawl, or through interception of an aquifer by cuts or excavations?	_	_	X
h. Substantial reduction in the amount of water otherwise available for public water supplies?	_	_	X
i. Exposure of people or property to water-related hazards such as flooding or tidal waves?	_	_	X
4. Plant Life. Will the proposal result in:			
a. Changes in the diversity of species, or number of any species of plants (including trees, shrubs, grass, crops, and aquatic plants)?	_	_	X
b. Reduction of the number of any unique, rare or endangered species of plants?	_	_	X
c. Introduction of new species of plants into an area, or barrier to the normal replenishment of existing species?	_	_	X
d. Reduction in acreage of any agricultural crop?	P	_	_
5. Animal Life? Will the proposal result in:			
a. Change in the diversity of species, or numbers of any animal species (birds, land animals, including reptiles, fish and shellfish, benthic organisms or insects)?	_	_	X
b. Reduction in the number of any unique, rare, or endangered species of animals?	P_	_	
c. Introduction of new species of animals into an area, a barrier to the migration or movement of animals?	_	_	X
d. Deterioration of existing fish or wildlife habitat?	_	_	X
6. Noise. Will the proposal result in:			
a. Increases in existing noise levels?		_	X
b. Exposure of people to severe noise levels?	_	_	X
7. Light & Glare. Will new light and glare occur?	_	_	X
8. Land Use. Will the proposal result in substantial alteration of the present or planned land use of an area?		_	X
9. Natural Resources. Will the proposal result in:			
a. Increase in rate of use of any natural resources?	_	_	X
b. Substantial depletion of any nonrenewable resource?	_	_	X
10. Risk of Upset. Will the proposal involve:			
a. Risk of explosion or release of hazardous substance (including but not limited to oil, pesticides, chemicals, or radiation) in the event of an accident or upset?	_	_	X
b. Possible interference with an emergency response plan or an emergency evacuation plan?	_	_	X

	Yes	Maybe	No
11. Population. Will the proposal alter the location, distribution, density, or growth rate of the human population of an area?	_	X_	
12. Housing. Will the proposal affect existing housing or create a demand for additional housing?	_	X	
13. Transportation/Circulation. Will the proposal:			
a. generate substantial additional vehicular movement?	_	X_	
b. affect existing parking facilities or demand for new parking?	_	X_	
c. Substantially impact existing transportation systems?	_	X_	
d. Alter present patterns of circulation or movement of people and/or goods?	_	X_	
e. Alter waterborne, rail, or air traffic?	_	X_	
f. Increase traffic hazards to motor vehicles, cyclists, or pedestrians?	_	X_	
14. Public Services. Will the proposal affect or result in a need for new or altered governmental services in these areas:			
a. Fire protection?	_	X_	
b. Police protection?	_	X_	
c. Schools?	_	X_	
d. Parks or other recreational facilities?	_	X_	
e. Maintenance of public facilities, including roads?	_	X_	
f. Other governmental services?	_	X_	
15. Energy. Will the proposal result in:			
a. Use of substantial amounts of fuel or energy?	P_	_	
b. Substantial increase in demand on existing sources of energy, or require development of new energy sources?	P_	_	
16. Utilities. Will the proposal result in a need for new systems or substantial alterations to the following utilities:			
a. Power or natural gas?	_	_	X
b. Communications systems?	_	_	X
c. Water?	_	_	X
d. Sewer or septic tanks?	_	_	X
e. Storm water damage?	_	_	X
f. Solid waste and disposal?	_	_	X
17. Human Health. Will the proposal result in:			
a. Creation of any health hazard or potential health hazard (excluding mental health)?	_	_	X
b. Exposure of people to potential health hazards?	_	_	X
18. Aesthetics. Will the proposal result in obstruction of any scenic vista or view open to the public, or will the proposal result in the creation of an aesthetically offensive site open to public view?	_	_	X
19. Recreation. Will the proposal affect the quality or quantity of existing recreational opportunities?	_	_	X
20. Cultural Resources. Will the proposal:			
a. result in alteration or destruction of a prehistoric or historic archeological site?	_	_	X
b. result in adverse physical or aesthetic effects to a prehistoric or historic building, structure, or object?	_	_	X
c. have the potential to cause a physical change that would affect unique ethnic cultural values?	_	_	X
d. restrict existing religious or sacred uses within the potential impact area?	_	_	X
21. Mandatory Findings of Significance.			
a. Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number of or restrict the range of a rare or endangered plant or animal, or eliminate important examples of the major periods of California history or prehistory?	_	_	X
b. Does the project have the potential to achieve short-term—to the disadvantage of long-term—environmental goals? (A short-term environmental impact is one that occurs in a relatively brief, definitive period, whereas long-term impacts will endure well into the future.)	_	_	X
c. Does the project have impacts that are individually limited but cumulatively considerable? (A project may impact two or more separate resources where the impact on each is relatively small but where the effect of the total impacts on the environment is significant.)	_	_	X
d. Does the project have environmental effects that will cause substantial adverse effects on human beings either directly or indirectly?	_	_	X

of land, zoning policies of the local governments, available public services, etc. The proposed project cannot independently have significant effects on future housing characteristics in any region.

Transportation and Public Services. To the extent that this project may play a role in the population and housing characteristics of the State, it may have secondary impacts on the transportation and public service systems.

Mitigation Measures

Objectives of the NDP include improvement of existing conditions in the south Delta; therefore, mitigation and enhancement features are an integral part of north Delta planning.

Mitigation for Delta Estuary Impacts

This section discusses the various categories of Delta mitigation applicable to the NDP. These are in addition to the Delta protective measures discussed in Chapter 1 and other mitigation measures discussed in Chapter 6.

Included in the purpose of the NDP are objectives to improve Delta conditions; therefore, mitigation and enhancement features are an integral part of this planning. Coordination between this program and other DWR planning activities, such as South and West Delta Water Management Programs, will provide environmental benefits.

Other aspects of mitigation discussed for this project include measures for short-term construction impacts and energy impacts.

Mitigation for cumulative impacts related to the Delta is discussed in Chapter 6. This includes such measures as compliance with Decision D-1485 protective standards, federal protection under the COA, Suisun Marsh Protection, funding for the Interagency Ecological Study Program, and implementation of the Banks Pumping Plant Fish Agreement for the Harvey O. Banks Pumping Plant.

Proposed integrated facilities that will provide for mitigation measures are as follows:

- Levee setbacks will be used to provide channel enlargements. A new levee will be constructed and the old levee will be breached and made into a new channel island. Levee setbacks will provide new high-quality fish and wildlife habitat, added shoreline, shaded riverine habitat, additional local flood protection, and increased channel capacity.
- Water management activities are to reduce SWP export buildup rates. By 2010, DWR expects that extraordinary conservation water management actions

  will be needed to reduce demand 400,000 AF to account for shortages that may occur 10 percent of the time. Water reclamation is assumed to add 200,000 AF of supply. Also, water savings by lining of the entire All American Canal and the remaining unlined portion of the Coachella Canal should make up to 117,000 AF available annually to the South Coast Region. All of these measures will reduce the demand for water from the Delta. In addition to these measures, DWR is continuing to advance the major water conservation programs discussed in Chapter 3.
- Negotiations to expand the existing Banks Pumping Plant Fish Agreement for the Banks Pumping Plant are in progress under Article VII of that agreement.
- The principal negotiators are DWR, DFG, and Reclamation. To date, the negotiators have identified a number of promising mitigation ideas, which are listed below. Some may be funded to add to the mitigation provision for the NDP.
- Study and test Delta Cross Channel gate closures to move striped bass down the Sacramento River.
- Study and test the concept of using pulse flows from Shasta, Oroville and Folsom lakes to move both striped bass and salmon downstream.
- Continue support for studies on the effect of temperature and flows and how project operations might be improved to benefit fish and wildlife.
- Install temporary barriers and monitor benefits to fish and wildlife.
- Improve existing fish facilities at Tracy and Banks Pumping Plants.
- Study the feasibility of relocating and consolidating Delta agricultural diversions. The proposal for a wildlife management plan on Sherman Island with potential different water demands may allow curtailed diversion during the striped bass spawning period. With possible changes in land use, other islands might curtail diversion.
- Support increased State and federal funding for mitigation studies and projects.

Environmental Commitments

- *Negotiate with DFG according to Article VII of the existing Banks Pumping Plant Fish Agreement to identify additional protective measures for the Bay-Delta estuary.*
- *Participate in development of fish protection measures according to an existing agreement, including a striped bass grow-out facility at SWP facilities and upstream measures to improve spawning.*
- *Continue existing – and, if necessary, expand – monitoring programs for sedimentation, scouring, seepage, water quality, and the effectiveness of mitigation plans.*
- *Protect wildlife and endangered species habitat losses by participating in the Stone Lake Wildlife Refuge program and protecting north Delta islands from flooding.*
- *Create high-quality channel berm habitat for rare plants by levee setback designs.*
- *Mitigate for construction impacts, including dust control and off-peak hours for transportation and replanting impacted vegetation.*
- *Mitigate for energy impacts, including best use of off-peak energy supplies, and project energy efficiency program.*
- *Perform comprehensive testing of dredged materials if used for enhancement of existing levees or construction of new levees.*
- *Advance drinking water investigations to provide for planning decisions to improve source water and treatment processes.*
- *Continue compliance with safeguards of laws, regulatory permits and water rights standards.*
- *Advance Suisun Marsh protective activities, including new facilities to implement the Protection Agreement.*
- *Provide protection for Delta M&I and agricultrural water users through project operations and contract management.*
- *Continue multi-million dollar environmental investigations to help determine Bay-Delta estuary corrective measures.*
- *Obtain the necessary federal and State regulatory permits.*
- *Operate SWP under the preferred alternative to not conflict with any requirements imposed on DWR by the State and federal Endangered Species Acts.*
- *Complete the necessary archeological and cultural resources surveys for the selected alternatives. If any sites are found to be eligible for the National Register and cannot be avoided, a mitigation plan will be developed.*
- *Continue advancement of statewide water conservation and reclamation programs to lessen the demand on Delta water supplies.*
- *Participate in a recovery team for winter-run salmon and obtain appropriate agreements or permits.*
- *Operate the SWP in compliance with future Delta standards set by SWRCB as the result of current hearings.*
- *Implement the Delta Flood Protection Act to protect the environmentally rich Delta lands from inundation. Levee improvements will be made without any net loss of existing habitat.*

- Transport young fish by truck or barge to increase survival.
- Eliminate reverse flow in the Lower San Joaquin River during the striped bass spawning period by implementing the North Delta Program.
- Support the feasibility of installing fish screens on other large Delta diversions.
- Continue to improve striped bass hatchery populations and expand stocking program.
- Continue to improve grow-out facilities at the Skinner Fish Facility.
- Support studies to improve techniques to better detect large masses (clusters) of striped bass eggs and larvae as they drift downstream and approach major water intakes.

Energy Mitigation

To the extent that water deliveries through the SWP system are increased by implementation of the NDP, State Water Project energy requirements will also increase. Inefficient, wasteful, or unnecessary energy consumption will be avoided by such measures as water conservation, energy recovery (estimated at 700 GWh) along the system, cost-effective improvement in machinery, and minimal use of on-peak energy. Such measures are included in DWR's energy program, and were incorporated in the economic analysis, which also considered the high costs of energy and capacity.

The remaining 600 GWh required would be an increment to SWP system power requirements. These figures are based on an increase of 172,000 AF in pumping at the Banks Pumping Plant in a median year. The 600 GW*h* is approximately equivalent to 100 MW of base load power plant running at 65 percent capacity.

The specific source of *600 GWh* cannot be determined at this time. It could come from any combination of existing power resources to which DWR has access, which, with interconnections, could number in the hundreds. DWR plans no new resource to meet this increase in project load. In its resource planning, however, DWR projects future purchases of 100-MW blocks of unspecified generic baseload. For costing purposes, these blocks represent shares in existing or future coal plants.

Mitigation measures employed in constructing and operating a typical coal plant include:

- A sulfur dioxide scrubber to remove at least 85 percent of the sulfur dioxide in the flue gas.
- An electrostatic precipitator to remove virtually all of the fly ash from the flue gas. Improve the boiler design to limit nitrous oxide emissions to a maximum of 0.6 lbs/1,000,000 BTU.
- Dust abatement provisions for the coal-handling and storage system.

Overall mitigation for increased power requirements is incorporated into: 1) environmental impact reports and design features for specific water and power facilities, (2 coordination between utilities of power sources and power uses, 3) efficient use of water supplies, and 4) best use of off-peak power supplies to delay construction of new generating facilities.

Chapter 6. CUMULATIVE IMPACTS

This chapter discusses cumulative impacts on the San Francisco Bay-Delta estuary, including the North Delta Water Management Program (NDP), cumulative impacts of State Water Project (SWP) deliveries in the service areas, and potential mitigation measures for cumulative impacts. Federal, State, and local planning, as well as other projects related to the Delta, are also discussed.

In general, *cumulative impacts* refer to two or more individual effects that are significant when considered together, or that compound or increase other environmental impacts. Cumulative impacts from several projects are changes in the environment that result from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable future projects. Cumulative impacts can result from individually minor, but collectively significant, projects taking place over time.

General Impacts of Past and Present Development

Many forces affect the complex Bay-Delta estuary environment. Changes have occurred in six general areas:

- Bay and Delta land changes, reclamation, and flooding;
- population;
- pollution and water quality;
- recreation;
- fish and wildlife; and
- Delta and Bay hydrology.

Implementation of the NDP would be associated primarily with cumulative effects on four general areas; however, all six areas are discussed, because the relationships between them are complex and interwoven. Table 6-1 summarizes general effects on the San Francisco Bay-Delta Estuary that would result from implementation of the program.

Table 6-1
General Effects of NDP on Past and Present Bay-Delta Estuary Cumulative Impacts

General Area Affected	Effects of NDP
Reclamation	Provides for added wetlands through design modifications and mitigation.
Delta flooding	Substantially increased channel capacity.
Population	No change.
Pollution and water quality	Improved SWP water quality due to reduced reverse flows. Also, improved circulation.
Recreation	Increased recreational opportun-ties and access.
Fish & wildlife	Some benefits for striped bass. Minimal impacts on salmonids and some resident fishes and benefits for wildlife.
Delta hydrology	Minor changes to outflow.
Bay hydrology	Minor effect on outflow surges.

Reclamation. In 1850, there were about 300 square miles of marshlands and more than 250 square miles of tidal and submerged lands in San Francisco Bay area. Due to reclamation, little more than 75 square miles of marshland, and only about 150 miles of tidal and submerged lands remained unchanged. Of this, almost half, mostly along the southern sections of San Francisco Bay, was originally reclaimed for salt ponds. Large areas in the north and south bays have been reclaimed for airports. Thus, reclamation has cumulatively reduced valuable riparian and wetland habitat for many Bay-Delta species.

The NDP will provide a more valuable natural riparian and wetland habitat by the following three methods: First, the design of facilities will recognize the importance of natural habitat. Channels will be enlarged by constructing new setback levees on agricultural lands, and maintaining the old levee as a new channel island. This will provide miles of new habitat, as well as new channel and water areas.

Second, as facilities are designed, recreational needs will be considered, and both the land and opportunity for additional recreational use will be available. New channels and new berm islands will also provide opportunities for natural areas and recreation.

Third, some interest has been shown by landowners of Twitchell Island and by county interests involved with the

Yolo bypass concerning conversion of various amounts of cultivated acreage to dedicated wetlands and/or wildlife habitat. DWR will coordinate with Yolo County regarding this matter and discuss possible funding.

Delta Flooding. In its natural environment about 140 years ago, the Delta consisted of tidal swamp, overflow lands, and grasslands covered with dense growths of tules and other water-loving vegetation. It was subject to intermittent intrusion of ocean salts during the dry summer months of lean water years and to uncontrolled flooding during winter and spring.

Over the years, the former swamplands of the Delta have been transformed into some 50 man-made reclaimed islands and tracts, largely devoted to farming. By 1930, all swamplands considered feasible for reclamation had been leveed and were being farmed.

The fertile Delta islands are defined by more than 1,000 miles of levees that protect nearly 500,000 acres of productive farmland. Maintaining this fragile levee system has been a continuous problem since the original reclamation began in the 1890s; more than 100 levee failures have occurred since then. Even with today's construction equipment and improved governmental assistance, there have been 24 levee failures since 1980. Reclamation of inundated islands has become so expensive that in some cases they have been left flooded (Franks Tract, lower Sherman, Little Franks Tract, Big Break, and Mildred Islands). To date, State and federal disaster assistance have provided $65 million to repair levee breaks. Some adverse effects of levee failures include:

- degradation of Delta water quality;
- loss of agricultural production;
- major disaster fund expenditures;
- loss of wildlife habitat and effects on fish;
- urban damage; and
- disruption of utilities, gas well production, and highway traffic.

The NDP facilities will lessen water quality degradation, reduce the frequency of flooding, and decrease the damage from a 1986 type of event by reducing the number of islands flooded and the cost of flooding.

Population. Populations in the San Francisco Bay-Delta area has risen from 5.8 million in 1980 to 6.3 million in 1985, an 8 percent increase. An increase to 7.9 million in 2010 has been forecasted—a growth of 26 percent. This population growth will affect water supply and demand, water quality, air quality, plant and animal life, noise pollution, land use, housing, and esthetics. Population increases in local service areas are discussed in Chapter 5. None of the NDP facilities or proposed operations will affect population forecasts.

Pollution and Water Quality. Overall, the Interagency Delta Health Aspects Monitoring Program studies have shown the Delta to be an acceptable source of water, which, when treated, meets existing drinking water standards. In the future, however, water exported from the Delta may be more difficult and expensive to treat if expected new water quality standards are adopted. Also, export water quality could possibly be improved by certain proposed new construction, such as enlargement of Clifton Court Forebay, and by water project operations in the Delta.

The major source of Delta inflow is the Sacramento River, which drains the Sacramento Valley. This includes rice field drainage containing pesticides. During the rice-growing season, up to one-third of the Sacramento River inflow can consist of rice field drain water, and during very wet years, Valley drainage can enter the Delta and Cache Slough via the Yolo Bypass system.

The San Joaquin River is the second major tributary providing Delta inflow. The river carries considerable salts from irrigation drainage and other sources in the San Joaquin Valley.

The San Joaquin River has been the subject of recent concern regarding its effect on Delta water supplies. Data collected by the Department of Water Resources (DWR) and from other sources indicate that San Joaquin River water is not higher in pesticide concentrations than that of other streams tributary to the Delta, such as the Sacramento River. Pesticide levels in water samples from all streams measured were far below established drinking water limits. Selenium data collected by DWR and the U.S. Geological Survey (USGS) demonstrate that the San Joaquin River is not now significantly degrading Delta water supplies, although the possibility of future adverse impacts cannot be dismissed.

Near the Delta, more than 50 municipal and industrial waste dischargers release about 453,000 acre-feet (TAF) of waste water annually. In addition, drainage from Delta agriculture totals over 1 million acre-feet (MAF) annually.

The rate of flow of uncontrolled direct surface runoff entering San Francisco Bay is nearly the same as the flow rate of municipal and industrial waste water (975 cfs vs 790 cfs). Certain parameters, such as 5-day biological oxygen demand (BOD) and nitrogen loadings, are, as expected, much higher from waste water sources. However, several times as much pollution enters San Francisco Bay via direct surface runoff; therefore, this is the largest single source of pollution.

Sound water resources management requires comprehensive data collection to enable understanding of factors that can adversely affect water quality. Toward this goal, DWR, in cooperation with other agencies, initiated the Interagency Delta Health Aspects Monitoring Program in 1983.

This program is vital to fulfillment of DWR's mission of water resource planning and drinking water protection in California. The program was developed in response to recommendations by a scientific panel appointed by the DWR Director to assess the quality of Delta water supplies as it affects human health. The program focuses on sodium, bromide, selenium, asbestos, trihalomethane precursors, and pesticides, all of which are important because of their potential effects on public health.

The NDP will not impact the winter-run salmon 10-point plan as proposed by the recovery team and will not add cumulative impacts to endangered species nor violate the law. The program will substantially reduce reverse flows in the lower San Joaquin River. This, together with improved circulation in the central Delta, will improve local and SWP water quality.

Additional discussion of toxics and pollution is presented in the section titled "Fish and Wildlife."

Drinking Water Quality. The preferred alternative in conjunction with other programs will have additional water quality benefits for drinking water supplies. The interrelationship of water supply planning and the Delta as a source of drinking water is recognized by DWR and other water agencies. Numerous water resources programs and studies have been initiated to understand this relationship and to implement projects that will improve both supply and quality of water. The following programs and studies describe the efforts being made to assure water quality protections and water supply benefits.

The South Delta Water Management Program (SDWMP) represents parallel planning and environmental documentation to improve existing conditions in the southern Delta. This planning and environmental documentation process is not intended to alter responsibilities under the South Delta Agreement. The program includes a public review of problems, alternative solutions, impacts, and mitigation to provide information for selecting corrective action. This process will help bring to light the many interests and concerns related to water resources planning in the south Delta. The program will also include an investigation of the cumulative effects of any corrective action when coupled with other facilities both statewide and in the Delta.

Multiple objectives will be considered to meet the broad range of water management issues surrounding the Delta. The particular objectives of the South Delta Agreement and, in turn, the SDWMP are to improve and maintain water levels, circulation patterns, and quality. Evaluation of multipurpose alternatives to meet those objectives will also take into account broader activities of Reclamation and DWR, which are to upgrade the reliability of water supplies; increase the efficiency of SWP and CVP operations; and enhance navigation, fishery conditions, flood control, and recreational opportunities.

The West Delta Water Management Program (WDWMP) will improve the levees protecting Sherman Island, thus reducing the possibility of salinity intrusion into the Delta due to island flooding. WDWMP also proposes to change the land use of Sherman Island from agriculture to wildlife habitat. This change would reduce or eliminate subsidence, helping to reduce island flooding potential. THMFPs in the west Delta would also be reduced because: 1) the potential for salinity intrusion from the Pacific Ocean (a source of THMFPs) due to Sherman Island flooding will be less and, 2) less agricultural drainage water, which has a high concentration of THMFPs, would be released into the Delta channels due to the change in land use.

Under low-flow conditions, the Sacramento River has about 215 ppb THMFP, with a brominated fraction of about 6 percent. Water in the western Delta near Sherman Island has about 1,000 ppb THMFP, with a brominated fraction of 90 percent.

Senate Bill 34 (SB 34) allocates funds to protect Delta islands from flooding and provides protection against short- and long-term water quality degradation in the Delta. If a levee fails and a large Delta island becomes flooded during an extended low-flow period, salty water from Suisun Bay could be drawn into the Delta. This would adversely affect Delta water quality and diversions for the SWP and the CVP, and extra releases from upstream reservoirs would be required to flush out the salts. If the levee is repaired and the flooded island pumped out, effects on project operation would be short term. Such short-term water quality problems do not occur if a levee breaks during periods of high winter flows, which would keep salt water out of the Delta.

If a flooded island is not reclaimed, long-term water problems could affect the SWP and the CVP. Evaporation from a flooded island exceeds the consumptive use of agriculture by up to 2 feet per year. Permanent flooding of certain western Delta islands could increase salinity intrusion and cost the projects additional water to maintain water quality.

The New Melones Conjunctive Use Program will help improve water quality in the south Delta by increasing flows in the San Joaquin River during dry and critically-dry years. Two central valley water agencies have firm water rights to 49,000 AF of New Melones water and 106,000 AF of interim water. Current negotiations between these two agencies and DWR involve release of this water into the San Joaquin River during dry and critically-dry years in return for state cost sharing in building water transfer facilities to transport the water from New Melones Reservoir to the two water agencies during normal and wet years. The increased San Joaquin River flows will dilute the concentration of contaminants in the San Joaquin River and Delta, thus improving water quality.

The Interagency Delta Health Aspects Monitoring Program (IDHAMP) was created to obtain water quality information that will help in making decisions about water quality and to assess potential water treatment methods in the Delta. IDHAMP has been collecting data at 20 locations in and near the Delta since 1983. The major findings and conclusions listed below are extracted from IDHAMP's report *The Delta as a Source of Drinking Water: Summary of Monitoring Results 1983 to 1987*, January, 1989.

- Studies have shown that the Delta is an acceptable water source. Once treated, Delta water meets all current water quality standards.

- Proposed drinking water standards for THMs and disinfection by-products may necessitate modifications in drinking water treatment processes or in the operation of Delta export facilities.

- Data from a few Delta island agricultural drains suggest that peat soils contain high concentrations of organic THM precursors. Organic THM precursors are also carried into the Delta by river inflows and saltwater intrusion.

- Bromides enter the Delta during episodes of saltwater intrusion and increase brominated THM production. The San Joaquin River is a fresh water source of bromides, the origin of which is unknown. Brominated THMs can be difficult to treat because they readily form during conventional disinfection processes.

- Pesticides and industrial chemicals are infrequently detected in Delta water. When detected, concentrations have been very low and do not exceed drinking water standards.

- Sodium is rarely a problem in Delta export water, except to people on very strict low-sodium diets. However, during low Delta outflows, sodium concentrations may rise to levels of concern to those with moderate sodium restrictions.

- Asbestos fiber counts are often high in Delta water. However, properly operated water treatment facilities can meet the proposed drinking water standard for asbestos.

- Selenium is barely measurable in Delta export water. The San Joaquin River does contain measurable amounts of selenium, but it does not exceed drinking water standards. During a sampling study period from 1984–1987, selenium values never exceeded the drinking water standard of 10 mg/l at any of the IDHAMP stations. Of 257 total samples taken at 18 locations over the study period, selenium was undetectable at the 1 mg/l detection limit 199 times. Selenium was never observed to exceed 3 mg/l.

In 1987, an Agriculture Drainage Investigation was added to IDHAMP to determine the influence of agriculture drainage on Delta water quality. The preliminary results of the investigation indicate that THMFP concentrations are influenced by soil type, crop production and crop type, soil leaching practices, and flow volume in the Delta channels. An enlarged monitoring program was recommended as necessary to characterize the variability of THMFP and flows of Delta agricultural drainage.

Additional future studies recommended by IDHAMP include:

- sources of THMFP and bromides in the San Joaquin River and the San Joaquin River influences on water quality in the Delta;
- algal production as a potential source of organic THMFP in the Delta, Suisun Marsh, and SWP;
- relationship between THMFPs present at the Banks Pumping Plant and in the water delivered to Southern California; and
- effects of proposed water facilities and operational changes of existing water facilities on water quality in the Delta.

The California Urban Water Agencies (CUWA) recently financed a study to determine changes in operation of the existing water facilities or construction of new facilities that will allow the Delta to remain as a viable future source of drinking water. The study, reported in *Delta Drinking Water Quality Study,* May, 1989, by Brown and Caldwell Consulting Engineers, outlines current water quality in the Delta with the present water facilities, and the possible water quality improvements if other previously and currently considered water resources facilities are implemented. This study shows that these Delta facilities could improve water quality in the Delta. Higher quality Delta water would reduce the cost and complexity of treating drinking water to meet standards and increase the possibility that treatment plants could reliably remove contaminants from the water.

In anticipation of EPA's probable further restrictions on drinking water quality standards, MWD initiated a two-year study of three water treatment processes: 1) granular activated carbon (GAC), 2) ozone, and 3) peroxone, which is a combination of ozone and hydrogen peroxide. Preliminary results indicate that peroxone provides the best results in reducing THM levels (below 2 or 3 parts per billion). Demonstration-scale tests of both ozone and peroxone, the two best and least-costly processes, should be conducted by MWD in 1991.

DWR is upgrading its Delta water quality modeling to include simulation of the dynamics of TDS loading by Delta agriculture drainage returns. This effort will enable DWR to improve its evaluation of salinity patterns in the interior Delta, particularly the south Delta.

Assembly Bill 955 (AB 955) instructed DWR to coordinate with Reclamation to develop emergency plans to quickly resume exports by the SWP, CVP, EBMUD, and Contra Costa Water District in the event of a levee failure in the Delta. The emergency plans—which are outlined in a December 1986 DWR report, *Sacramento–San Joaquin Delta Emergency Water Plan: Report to the Legislature*—prescribe various procedures that, if enacted, would maintain adequate Delta water quality and resume export operations.

Recreation. Along with population, water-oriented recreation in the Delta has increased to some 12 million visitor-days in 1980 and is expected to reach almost 14 million in 2010. This will increase fishing and boating pressure. The NDP will provide both land and opportunity for increased recreation and access.

Fish and Wildlife. During the past century, the estuary has undergone some dramatic changes. Land reclamation, dredging, water development projects, introduction of new species, water pollution, and excessive fishing have caused some resources to decline. Many of the commercial fisheries began to diminish before the turn of the century. Since 1970, a portion of the Interagency Ecological Studies Program's work in San Francisco Bay-Delta has been to distinguish the impacts of State and federal water projects from the impacts of other natural and cultural factors, such as flood and drought, pollutants, and introduced species.

Introduced species fall into two categories—intentional and accidental. Many species were introduced in the late 1800s and early 1900s to provide fish that would be recognized by recent immigrants. Striped bass, carp, goldfish, catfish, sunfish, largemouth bass, and American shad were brought into California. In many cases, these fish displaced native species and are now accepted by most Californians. Project operations are often modified to protect them, particularly striped bass and American shad. Current Department of Fish and Game (DFG) policy is to severely restrict the introduction of further new species into California. Still, accidental introductions of other various organisms are continuing in the estuary, possibly affecting the estuary's ability to provide suitable habitat for game fish.

Recently, large numbers of a small clam, a small fish called the chameleon goby, and two small fish food organisms called copepods have been found in a portion of the upper estuary that has long been the nursery grounds for young striped bass. These new arrivals apparently came from the Orient by way of ballast water pumped from ships into the San Francisco Bay–Delta. The food chain of striped bass and other fish can be disrupted by competition from the clam and the goby. The native copepod species, which has been the preferred food for recently hatched larval bass, may be displaced by the introduced copepod. The appearance of these new organisms may be one of a number of reasons why fewer young striped bass are produced now than during the 1960s and early 1970s.

The plant and animal community in the San Francisco Bay–Delta is constantly changing. Natural resource and regulatory agencies must be made aware of these changes when they try to assess project impacts and define reasonable levels of protection. If these introductions have caused changes in basic system productivity, it may be impossible to determine historic population levels.

In May 1989, the California Fish and Game Commission listed the winter–run Chinook salmon as endangered, based in part on estimates by DFG that the population of the run was under 600, down from what had appeared to be a stable 2,000. Under State law, after the Commission determines the basis for listing a species, it must adopt a regulation to that effect.

The National Marine Fisheries Service (NMFS) listed their winter run as threatened under an emergency listing in August 1989.

The basic provisions of both sets of regulations prohibit "takings" of listed species and require an agency involved in activities that could jeopardize the listed species to consult with the appropriate fishery agency. Taking is defined very broadly. Violations can lead to civil and criminal actions. DWR will be working closely with DFG and NMFS to determine exactly how the listings will affect DWR and Reclamation Board activities and programs.

An extensive hearing procedure aimed at developing new water quality objectives for the San Francisco Bay–Delta estuary and the means to achieve them began in July 1987. During phase one of the hearings, considerable disagreement arose over the impact of water development on the health of San Francisco Bay–Delta fisheries. Declining striped bass populations also received considerable attention.

Salmon populations have been relatively stable. Hatchery production has increased, and thus is compensating for the decline in natural production.

Reverse flows, which can occur under controlled flow situations, also contribute to the fishery decline. Reverse flows consist of export water flowing down the Sacramento River to the vicinity of Sherman Island and then upstream (hence the term *reverse flow)* in the San Joaquin River to State and federal pumps. This route results in many young salmon and bass being either directly drawn into the pumps or disoriented from their historical migration paths.

Some reports have concluded that changes in fresh water outflow cause significant biological changes in estuaries of all types. Changes result, in most cases, from responses by organisms to physical conditions such as altered circulation patterns, increased salinities, and reduced nutrient input. The ecological significance of these changes is not completely defined in most systems. In some cases, the same flow change favors some organisms and affects others adversely. Biological responses to flow are difficult to document because the cause–and–effect relationship between flows and organism abundances generally operates through a chain of events rather than direct effects of flow alterations on abundance.

Historical biological resources in the Delta were quite different from the existing resources. Upstream dredging and hydraulic mining in the 19th century deposited large amounts of sediment and debris throughout the Delta, burying biological communities and changing hydrologic and hydraulic characteristics.

Agricultural development in the late 1800s and early 1900s resulted in major habitat modifications. As early as 1920, nearly all the Delta marshlands had been diked and converted to farmland. Less than 10 percent of the original bay marshlands remain. Physical, chemical, and biological processes were changed dramatically.

Historically, natural levees formed along the edges of many of the Delta's tule islands and supported woody riparian vegetation. Historical navigation charts show tall trees and shrubs along the banks of major Delta channels.

Presumably, most of the Delta's woody riparian vegetation was eliminated many years ago to provide water-front–access farmland, and wood for fuel and construction. Maintenance of present–day levee banks prevents the growth of most large trees and shrubs.

Wildlife habitat or cover types in the north Delta are agricultural, forest, riparian forest, riparian scrub, emergent fresh water marsh, and heavily shaded riverine aquatic.

The California Natural Diversity Data Base has assigned both the riparian forest and fresh water marsh its highest priority because of its almost complete destruction in the Central Valley.

Rare, threatened, and endangered plant and animal species that may be found in the project area are discussed in Chapter 5.

The NDP will:

- provide for wetlands as stated above under "Reclamation";
- create improved striped bass habitat through reduction of reverse flow;
- provide for mitigation in connection with negotiations for a Delta fish protective agreement; and
- provide additional shoreline and habitat.

Delta Hydrology. Natural features of the San Francisco Bay–Delta estuary affecting the environment are ocean tides and salinities, inflows of fresh water, and interior Delta flow patterns. Ocean salinity intrusion varies with fresh water inflow rates. Tidal fluctuations occur in regular cycles throughout the year. Natural tributary inflow to the Delta is controlled by the climate and varies greatly from season to season and from year to year. Before major upstream regulation, low dry–season inflow often allowed ocean salt water to intrude far into the estuary. In 1924, 1926, 1931, 1934, and 1939, chloride concentrations in nearly all Delta channels exceeded 1,000 milligrams per liter (mg/l).

Control and development of Central Valley streams to reclaim land and to produce the power and water needed for California's farms, homes, and industries have altered the seasonal pattern of river flows and reduced the amount of water reaching the ocean by way of the Delta. Wet–season flows are reduced principally by storage in upstream reservoirs and by exporting Delta inflows. Dry season flows are reduced by upstream uses, but releases from project reservoirs maintain Delta outflows at or above minimum protective levels specified by the State Water Resources Control Board (SWRCB). In the Central Valley, local water uses and exports for use elsewhere have reduced the unimpaired runoff from a 57–year historical annual average of 28 MAF to an annual Delta outflow of 13 MAF per year, a reduction of 15 MAF per year. Unimpaired runoff represents the natural water production of a river basin, unaltered by upstream diversions, storage and exports, or imports, but assuming existing channelization.

Delta outflow in an average year is the sum of:

- 5 MAF required to meet Decision 1485 requirements and to protect water quality at project export pumps, and
- 8 MAF of unregulated Delta outflow in excess of minimum requirements.

The 15 MAF–per–year reduction in unimpaired runoff includes:

- 1.6 MAF of local Delta use.
- 5.9 MAF of combined SWP and CVP water exported directly from the Delta for use both inside and outside the Central Valley.
- 7.5 MAF of upstream uses, including exports from the Central Valley via the Hetch Hetchy Aqueduct, Mokelumne River Aqueduct, Friant–Kern Canal, and other local projects.

The first phase of the NDP will add about 100 TAF to the SWP in the near future.

Bay Hydrology and Circulation. San Francisco Bay is often referred to as an "urbanized estuary" because of its proximity to such a large population center. Water circulation in San Francisco Bay is of major importance for many human uses of San Francisco Bay. Water movements disperse and eventually remove unwanted materials from the system.

Bay circulation is driven by three main factors: tides, estuarine circulation, and wind–induced mixing. Most water motion in San Francisco Bay is the result of tides. Filling and diking along San Francisco Bay over the years have changed the tidal range, which in turn has affected tidal flushing of San Francisco Bay. The average volume of water passing the Golden Gate during a single flood or ebb tide is about 1.1 MAF, which is about 20 percent of San Francisco Bay's total volume.

Estuarine circulation created by fresh water inflow from the Sacramento River system is also being studied as a factor affecting net transport into and out of San Francisco Bay. Estuarine circulation is driven by the difference in density between fresh water and salt water, which is related to Delta outflow. The importance of estuarine circulation, and its association with the effect of winter storms on salinity distribution in the southern reaches of San

Francisco Bay, is being investigated in connection with flushing the South Bay and controlling long-term buildup of toxic materials. Fresh water inflow to San Francisco Bay also provides large amounts of suspended sediments and nutrients, which contribute to San Francisco Bay's ecological balance. The NDP will have minor effects on inflow and inflow surges to the Bay.

Information presented by the State Water Contractors at San Francisco Bay-Delta Hearing suggests new and different evaluations of fresh water inflow to San Francisco Bay under natural conditions. The new factors considered in the evaluation of inflow have been popularly referred to as the "Tule Theory."

The Tule Theory. Before the Central Valley was developed, the valley trough functioned as a holding basin, filling and draining every year. Tule marshes choked these natural reservoirs, and riparian forests lined the stream channels along the valley floor. This natural vegetation took advantage of the plentiful supply of water, using far more than the irrigated crops that replaced them.

With development of the Central Valley following the Gold Rush, the natural flood basins were drained, the tule marshes and riparian forests were replaced by irrigated crops, and the upslope forests were harvested. The original sluggish, quasi-lakelike environment in the Central Valley was transformed into the highly channelized system, with very short hydraulic residence times and high velocities, that we know today. The principal result of upstream development has been: 1) replacement of the natural valley holding basins with man-made upstream storage reservoirs, and 2) replacement of the evaporative water losses by natural vegetation with consumptive use by crops and humans.

According to the "Tule Theory," fresh water inflow to San Francisco Bay from the Delta is presently about the same, on an annual basis, as it was under natural conditions. Drainage, reclamation, flood control, and water development in the Central Valley have not significantly affected the quantity of fresh water reaching San Francisco Bay. Early development in the Valley increased outflows while subsequent development reduced them to about their initial level. Evaporative water losses from the original marshes and riparian forests in the Central Valley exceeded present in-basin use and exports by about 110 percent. The monthly distribution of flow into San Francisco Bay was much more uniform under natural conditions than now, and winter and spring pulse flows that are common today were probably rare under natural conditions.

The timing of previous flow conditions can affect the type and magnitude of biological responses to outflow-related effects. These considerations make it difficult to establish statistically sound and predictable cause and effect relationships between outflow and biological parameters.

Other Factors. Many factors contribute to changes in the San Francisco Bay-Delta estuary system. Some of these will continue to affect the estuary, with or without the NDP. Others will be cumulatively impacted by incremental changes caused by the program. Some incremental changes may be beneficial, such as reduced reverse flows in the lower San Joaquin River with implementation of the NDP. Past, present, and future factors which have impacted, or will impact, the estuary include:

- land reclamation;
- sediment load from early hydraulic gold mining activities;
- waste water effluent and surface runoff from local and upstream urban development;
- oil spills;
- drainage and leaching water discharge from Delta and upstream agricultural water use;
- commercial, sport, and illegal fishing;
- construction and maintenance of deep water shipping channels;
- use of natural inflows by agricultural and urban development;
- changes in amount and variation of outflow;
- upstream storage and regulation of natural inflows by the CVP, SWP, Hetch Hetchy Aqueduct Project, Mokelumne Aqueduct Project, and local projects;
- Delta diversions by the CVP, SWP, local municipal and industrial water users, and Delta agricultural water users;
- levee failures in the Delta; and
- some positive beneficial effects due to improved environmental factors.

The NDP will add cumulatively to the regulation of Delta exports and outflows. The program will have an unknown effect on San Francisco Bay, but will add cumulatively to the environmental stress caused by other factors. Other moderating unknown effects are filling and reclamation.

SWP Planning and Related Projects

DWR planning programs for the Delta and related projects are discussed in this section.

South Delta Water Management Program

The South Delta Water Management Program (SDWMP) represents parallel planning and environmental documentation to improve existing conditions in the southern Delta. This planning and environmental documentation process is not intended to alter responsibilities under the South Delta Agreement. The program includes a public review of problems, alternative solutions, impacts, and mitigation to provide information for selecting corrective action. This process will help bring to light the many interests and concerns related to water resources planning in the south Delta. The program will also include an investigation of the cumulative effects of any corrective action when coupled with other facilities both statewide and in the Delta.

Multiple objectives will be considered to meet the broad range of water management issues surrounding the Delta. The particular objectives of the South Delta Agreement and, in turn, the SDWMP are to improve and maintain water levels, circulation patterns, and quality. Evaluation of multipurpose alternatives to meet those objectives will also take into account broader activities of Reclamation and DWR, which are to upgrade the reliability of water supplies; increase the efficiency of SWP and CVP operations; and enhance navigation, fishery conditions, flood control, and recreational opportunities.

Alternatives for achieving the water management goals in the south Delta include various elements from within three major project components: 1) direct water level and circulation, 2) Clifton Court Forebay modifications, and 3) related project modifications, including changes in operation. The selected projects may include a combination of elements from within the three project components that follow:

1. Direct water level and circulation improvements include:

- Middle River tide gate structure near Highway 4;
- Old River tide gate structure near Delta-Mendota Canal intake;
- Grant Line Canal tide gate structure near project facilities;
- Tom Paine Slough siphons;
- consideration of tide flow structures; and
- need to dredge certain channels.

2. Clifton Court modifications include:

- a new intake to Clifton Court Forebay;
- an enlarged Clifton Court Forebay with a new gate at the north end; and
- possible construction of levee setbacks.

3. Related Project modifications include:

- connection of CVP with Clifton Court Forebay;
- relocation of Contra Costa Canal intake to Clifton Court Forebay;
- entering into a conjunctive use program with local interests for New Melones releases into the south Delta; and
- modification of CVP and SWP operations.

The alternatives described would help achieve the broad objectives of the SDWMP in various ways.

Fishery benefits may be provided through a conjunctive use program with New Melones, which would provide additional flow down the San Joaquin River during periods critical to fish. Fishery benefits might also be realized through a winter banking program with use of storage south of the Delta. This could shift some pumping operations from spring and summer (periods critical to fish) to winter (when fish are less abundant). Another possible fishery benefit will result if flow patterns are altered to maintain more flow in the San Joaquin River to improve spring and fall salmon migration.

Proposed channel improvements could provide opportunities for development of additional recreation. Dredging would make accessible some scenic stretches of channels, such as Old River near Salmon Slough.

The proposed channel dredging would improve navigation by increasing water depth. Interconnection of the CVP with Clifton Court Forebay, along with operational modifications, could also improve navigation in south Delta channels during low tides.

West Delta Water Management Program

The West Delta Water Management Program (WDWMP) is centered on four major issues: flood control, water quality, wildlife concerns, and water supply reliability. The importance of these issues to the west Delta, and to the Delta as a whole, has necessitated a broadened scope of planning, including development of a wildlife management plan for Sherman Island.

Because of its location, the 10,000-acre Sherman Island is important in: 1) protecting the reliability and quality of the Delta water supply, 2) providing wildlife habitat, and 3) protecting highways and utilities. The island is the focus of the WDWMP. Its objectives are to:

- improve levees for flood control;
- protect Delta water quality;
- implement the wildlife plan, which will include acquisition of island properties for development of diverse waterfowl and wildlife habitats;
- meet water supply and water quality needs of Sherman Island;
- provide habitat for waterfowl and wildlife;
- minimize oxidation and subsidence;
- protect the reliability of SWP and CVP;
- identify potential wildlife habitat mitigation opportunities for present and future water development projects;
- protect highways and utilities; and
- provide additional recreational opportunities.

Alternatives for the WDWMP have been designed to allow a phased approach and flexibility in implementation. Phasing provides for lower initial costs and an opportunity to modify future phases based on information gained during initial phases. The process is being guided by the objectives discussed above, plus other considerations such as:

- maintaining the integrity of the island by reducing the rate of land subsidence, which is largely caused by present farming practices. The Farm Securities Act of 1987, administered by the U.S. Soil Conservation Service, mandates that soil conserving management practices must be developed to minimize soil erosion and loss.
- providing cost-sharing opportunities for special Delta flood control projects identified in Senate Bill 34;
- emphasizing development of wetland and riparian habitat. Senate Concurrent Resolution 28 emphasizes the importance of wetland habitat in California and mandates that DFG increase wetland habitat in the State;
- managing consumptive water use, while effectively providing habitat for wildlife;
- providing for flexibility in acquisition of lands or land use easements;
- providing flexibility in land use management options;
- providing an opportunity to incorporate habitat mitigation for SWP and CVP water management programs; and
- minimizing costs by using existing island water distribution systems.

The WDWMP is still in the implementation stage. Many factors are being considered to provide benefits and as much flexibility as possible. These include phased planning, land acquisition, cost sharing, nonproject levee rehabilitation, and mitigation banking. A necessary part of any program in the west Delta will be rehabilitation of the nonproject levees.

A phased planning approach can provide flexibility. Development of wildlife and wetland habitat can be accomplished progressively, and any of the alternatives discussed could be the starting point, possibly culminating in a full or partial wetland development plan. Phased planning also provides for a minimum acquisition plan, which initially would involve only a portion of the island. This concept allows a project to be initiated at the lowest possible cost.

Land acquisition options include direct purchase or some type of purchased easement that will ensure land management practices that benefit wildlife. Easements of this type have been successfully negotiated for similar wildlife management projects in California. In any case, acquisition of parcels will involve negotiations with the landowners. Selection of acquisition options will depend on landowners' needs and the type of alternative selected for implementation.

To protect any water management program investment for Sherman Island, nonproject levees on the island must be rehabilitated. This investment would also protect State Highway 160, utilities, Delta water quality, and reliability of project water supplies.

The degree to which these levees would be improved is not yet established. However, standards will be consistent with implementation of Senate Bill 34, a program of levee protection recently signed into law by the Governor. Rehabilitation of these levees will be common to all proposed water management program alternatives and will have high priority.

To provide an opportunity to incorporate habitat mitigation for SWP and CVP projects, including SDWMP and NDP, a mitigation banking concept may be applied to any of the wildlife management alternatives. In a mitigation banking plan, portions of Sherman Island would be developed as needed to mitigate habitat impacts from future water development projects. This would allow "in-kind" mitigation for project impacts.

The value of habitats established on the island as mitigation would depend on the type of habitat developed. Objectives can be established to achieve maximum benefits for wildlife. The mitigation bank would develop in an orderly fashion, with habitat types developed adjacent to each other rather than at random throughout the island. As with any of the alternatives, areas with common irrigation and drainage systems would be developed simultaneously to avoid duplication of construction efforts.

Coordination With D-1485 Rehearings

Decision 1485 focused solely on the water rights and operations of the two largest water projects, the SWP and the CVP (decision issued April 13, 1984, by Superior Court Judge Richard Figone). Reclamation and DWR were required to maintain Delta water quality according to standards based on "without project" conditions, as if the projects had never been built.

Lawsuits by various water users and the federal government challenged Decision 1485, which was overturned in 1984. However, the standards remained in force until a decision was issued by the Court of Appeal. In 1986, the appellate court broadly interpreted SWRCB's authority to establish and enforce water quality objectives that assure reasonable protection of beneficial uses of Delta water, as well as protection for San Francisco Bay. The ruling also ordered SWRCB to consider the effects of all upstream water uses, not just those of the SWP and CVP (ruling issued May 28, 1986, by presiding Judge John Rancanelli).

In July 1987, SWRCB opened Phase I of San Francisco Bay-Delta hearings to gather evidence on the beneficial uses of Bay-Delta water. After 54 days of testimony, cross examination, and rebuttal on 14 subjects, Phase I concluded in late December 1987.

A work plan guided the hearing process during the last couple of years. However, after SWRCB concluded Phase I and released its draft water quality and pollutant policy documents, it became clear that some provisions of the overall work plan needed revising. SWRCB requested staff to remove consideration of flow-only objectives from the water quality control phase (old Phase II) and defer this consideration to the water rights decision phase (Old phase III). It also asked staff to allow for greater development of implementation alternatives to water rights regulation. SWRCB indicated that the work plan should set forth an open and thorough process for the water quality control phase.

Initial drafts of the revised work plan include many opportunities for input from the hearing participants on the work plan, the revised water quality control plan, the pollutant policy document, and on other nonregulatory methods of protecting beneficial uses in the San Francisco Bay and Sacramento-San Joaquin Delta. With regard to the nonregulatory measures, the draft work plan allows for a scoping hearing on physical facilities, negotiated settlements, legislative action, and other agencies' responsibilities before the water rights phase begins. The draft work plan also specifically allows for input from technical workshops and DWR water planning efforts.

The first series of technical workshops deals with operation studies to analyze the impacts of the draft plan on the availability, allocation, and use of Central Valley water supplies. The second series of workshops deals with supply, demand, and water conservation evaluations. Urban and agricultural issues are considered in separate workshops, as are a Delta agricultural workshop and a public trust workshop.

Recently, the Metropolitan Water District of Southern California (MWD) and other major urban water users around the State requested and were granted a workshop series on trihalomethanes (THMs) and other constituents found in Delta drinking water supplies.

This open process should provide an improved plan but will take longer. Tentatively, SWRCB will adopt the water quality control plan in June or July 1990, and the hearing on water rights will begin after extensive scoping hearings, which have not yet been specifically scheduled.

Coordinated Operation Agreement

The essence of the Coordinated Operation Agreement (COA) is the sharing formula, which provides a CVP/SWP proportionate split of 75/25 responsibility for meeting in-basin use from stored water releases, and a 55/45 responsibility for the capture and export of excess flow. Both parties also agree to meet a specified set of Delta water quality standards (Exhibit A of the May 20, 1985, Agreement) from SWRCB Decision 1485. Exhibit A standards are a set of water quality standards and export and flow restrictions that define the Delta portion of in-basin use requirements.

These standards provide more environmental protection than the Reclamation's present water quality requirements, known as "Tracy Standards," by adding about 100 new protective criteria at 15 additional Delta locations. This agreement also requires a commitment of about 2.3 MAF from both projects during a critical water supply period to meet Delta outflow and quality protective needs.

Careful evaluation of all comments received on the Draft EIR/EIS revealed that no significant impacts would be caused by implementation of the COA; therefore, no mitigation was recommended. Also, many of the commenting agencies and individuals favored implementation of the COA.

The project has the potential to increase Delta inflow and export, and decrease Delta outflow. However, fish screening losses can potentially increase. The COA requires Delta protection, and there are possible mitigation alternatives.

The agreement was signed November 24, 1986, and is being implemented as required.

Wheeling-Purchase Negotiations Under Section 10 (h) of the Coordinated Operation Agreement. Current negotiations commenced in June 1987 and negotiators have met approximately 25 times. The negotiations are conducted in public, and public comment is permitted during the progress of the negotiations. This negotiating format has been most helpful in allowing an interchange of ideas during the negotiating process.

The USFWS, DFG, and SWRCB have been represented at the negotiating sessions and have made significant contributions. State and federal water contractors and various fishery and environmental groups have also been represented and have provided useful input.

The negotiators recognize the need for compliance with State and federal laws requiring environmental documentation. DWR and Reclamation initiated the EIR/EIS process in August and September 1989 by issuing a Notice of Preparation and Notice of Intent, respectively. Five scoping sessions were held in September 1989. Comments on the scope of the EIR/EIS were received and will be presented in a Scoping Report (now in preparation). A draft EIR/EIS is tentatively scheduled for release in late 1990.

The negotiators are concerned about the best method of meeting the requirements of federal reclamation law. The three following alternatives have been identified as workable:

- Devote the water to municipal and industrial uses which are not subject to the acreage limitations
- Use the agricultural commingling provisions of federal law and meet the reporting requirements of federal law on sufficient land to match the total quantity of CVP water taken for SWP use. Studies by the Kern County Water Agency (KCWA) indicate that sufficient acreage lies within the SWP service area to meet the requirements to cover the amount of CVP water the SWP is likely to purchase.
- Devote the CVP water purchased to Delta outflow, which would also be a purpose exempt from the federal acreage limitations.

All three methods appear viable, and DWR will be able to show Congress and the public that any one of them could be used. However, the DWR negotiators and the SWP contractors strongly favor the Delta outflow approach. Recently, the Reclamation negotiators have indicated their willingness to accept this approach, and DWR is currently drafting a proposed contract based on the outflow approach.

The negotiators are not entirely in agreement on a schedule, but still hope to have a draft contract proposal for consideration in 1990. It is the position of the DWR negotiators that environmental documentation of this proposal proceed, but not be presented to Congress until Reclamation receives approval from SWRCB to divert from Clifton Court Forebay. The Board is currently scheduling this as part of the water rights decision phase of its Delta hearings, which are now several years away.

H.O. Banks Delta Pumping Plant, Additional Units

The H.O. Banks Delta Pumping Plant was built to accommodate 11 units, but only 7 were initially installed. On December 30, 1987, a Notice of Determination was signed, and the installation schedule for the four additional units shifted from the planning phase to the design and construction phase. The new units, each with a design capacity of 1,067 cfs, are scheduled to be operational in 1991.

Completion of the Banks Pumping Plant will increase SWP delivery reliability and efficiency by increasing standby capacity for the existing units and by permitting a larger share of the pumping to be done with off-peak power. The new units will also allow a small amount of additional pumping to be shifted to the winter months. The additional units will only slightly change export, outflow, water quality, and fish and wildlife effects. The NDP will add about 100 TAF to the cumulative effects of this project.

The last four units of the Banks Pumping Plant will increase the total capacity of the pumping plant to 10,300 cfs, bringing the California Aqueduct up to its full design capacity between the Banks Pumping Plant and Bethany Reservoir. To protect the navigable capacity of the Delta waterways near the pumps, DWR limits diversions into Clifton Court Forebay to historical levels (Public Notice 5802A, amended October 1981). As long as the SWP follows the operational criteria published in Public Notice 5802A, no Corps permit is needed. However, if diversions into Clifton Court Forebay are to be increased beyond historical rates, a Corps permit will be required (under Section 10 of the River and Harbor Act of 1899).

Installation of the additional units will also increase the reliability of SWP water supply deliveries. Under the Corps constraints, the additional pumps could increase firm deliveries during critical water supply periods by about 60 TAF annually. This water, pumped during high-flow winter months, will partially offset the frequency and severity of projected shortages.

The additional pumping units will allow more pumping to be shifted to off-peak hours, when energy costs are lower. This will provide cost savings to SWP water contractors, as well as possibly delay the need to buy additional power or to construct additional power generating facilities.

Before the Notice of Determination could be signed, environmental concerns regarding the additional units at Banks Plant had to be addressed. A fishery agreement between DWR and DFG, signed on December 30, 1987, allowed work to continue on the final four units. The agreement spells out the steps needed to offset adverse fishery impacts by SWP Operations.

H.O. Banks Delta Pumping Plant, Fish Agreement

DWR and the DFG signed an agreement in December 1986 to mitigate direct fish losses at the Banks Pumping Plant complex. The agreement provides for DWR to make funding available for projects which will help to increase the survival of Chinook salmon, steelhead, and striped bass. The agreement requires two types of payment by DWR: 1) $15 million to initiate a program to quickly replenish fish populations depleted by SWP pumping and 2) annual payments based on the calculated numbers of fish lost at the complex.

DFG has estimated DWR mitigation responsibility for 1) about 544,000 striped bass, 631,000 Chinook salmon, and 22,000 steelhead in 1986; 2) 684,000 striped bass, 492,000 Chinook salmon, and 12,000 steelhead in 1987; and 3) 850,000 striped bass, 1,610,000 Chinook salmon, and 16,000 steelhead in 1988. All these figures are preliminary, and DWR has not agreed to any numbers until more is learned of predation in Clifton Court Forebay.

DWR's goal is to produce enough fish to replace those lost at the Banks Pumping Plant complex. Replacing the lost fish with hatchery fish would cost DWR about $1.4 million per year for 1986, 1987, and 1988. Other ways of replacing the fish—through development of spawning grounds or other environmental improvements—might cost less, depending on the number of fish produced.

Replacement Purchases. Payments for 1986 losses are being used in part to purchase yearling striped bass from private aquaculture firms. However, obtaining enough fish has proved difficult. Although aquaculture firms contracted in 1987 to supply about 550,000 yearlings for planting in 1988, the actual supply was only about 345,000. Currently, eight aquaculture firms are licensed to rear striped bass, and they have experienced problems during the sensitive spawning and early-life stages of the fish.

Skinner Fish Facility. To provide another source of yearling striped bass, DWR and DFG are operating a newly constructed fish rearing facility on the grounds of the Skinner Fish Facility. Fish salvaged at the facility screens were reared in tanks for release in spring 1989. About 117,000 fish from this project were planted in San Pablo Bay at Rodeo and in the Sacramento River at Rio Vista.

It appears that striped bass from the salvage operation can be grown successfully at the Skinner Fish Facility, but some modifications in plumbing and water supply were needed to ensure fish survival during hot weather. After the fish rearing facility has operated for two years, DWR will determine whether the State should continue to operate growout ponds in the Delta or other locations, or whether private growers should assume this task.

Streambed Improvements. Gravel was placed in Mill Creek (Upper Sacramento River) in time for the 1988 spawning season of fall Chinook salmon. Although it is difficult to quantify the benefits of such projects, Chinook salmon were observed spawning in the improved riffles.

Hatchery Improvements. Approximately $850,000 has been allocated to improving DFG's Merced River Fish Facility. The rebuilt facility will produce more Chinook salmon that are in better condition than those produced by the present operation. DWR will receive an annual credit of about 40,000 yearling Chinook salmon (at the Delta) as a result of this project.

Fish Screen. DWR and DFG have approved an expenditure of about $40,000 to install a screen on an existing small diversion in Suisun Marsh. The screen will benefit both Chinook salmon and striped bass, as well as other fish in marsh channels. The installation will also help evaluate the potential of screening the hundreds of similar small diversions scattered throughout the Delta.

Steelhead. DFG, under contract to the DWR, will allocate part of the production capacity of their Mokelumne River Hatchery to about 30,000 yearling steelhead. Because steelhead released into the Mokelumne River return at extremely low rates, yearlings from this program will be released into the American River.

New and Potential Projects. These include:

- extra striped bass plants,
- Sacramento River spawning gravel improvements,
- Glenn-Colusa fish screen assistance,
- flow augmentation on rivers tributary to the Sacramento River,
- flow augmentation on rivers tributary to the San Joaquin River, and
- construction of a permanent Old River barrier.

Testing. The 1989 San Joaquin River salmon tests involved the coordination of several upstream water operators to concentrate fish mitigation releases from various tributaries, in one week, to produce flows of 2,000 to 2,500 cfs timed to arrive at Vernalis together. (DWR and Reclamation will reduce exports or increase upstream releases to equal this inflow.) Tagged salmon released from several locations will be counted again in early 1992 to define the benefits that can be attained by constructing a barrier or installing a fish diversion on Old River at the confluence of the San Joaquin River.

Temperature testing in the north Delta will involve releasing three batches of salmon from various locations on the Sacramento River between Sacramento and Ryde at water temperatures of about 60, 65, and 70 degrees Fahrenheit. The objective of these tests is to determine whether water temperature is more important to fish survival than river flows.

Article VII Negotiations. On execution of the Banks Pumping Plant Fish Agreement, the parties began discussions, as stated in Article VII, of developing methods to offset the adverse fishery impacts of SWP that are not covered by the agreement. Included are facilities needed to offset fishery impacts and more efficient conveyance of water.

DWR and DFG are continuing to examine and evaluate potential striped bass and Chinook salmon projects as they are developed. An advisory committee representing fishery, environmental, and water user interests has been established to assist in evaluating and selecting projects. The agencies are also evaluating the factors used to calculate mitigation losses and will make adjustments as needed.

SB 34—Delta Flood Protection Act

Senate Bill 34, enacted in 1988, creates the Delta Flood Protection Fund, to be funded from tidelands revenues currently designated by statute for the California Water Fund. The Bill authorizes $12 million a year for appropriation by the Legislature for a ten-year period of flood protection in the Sacramento-San Joaquin Delta. Specifically, $6 million is allocated to the Delta Levee Maintenance Subventions Program, and the remaining $6 million is for special flood control projects for eight western Delta islands and the towns of Walnut Grove and Thornton.

Delta Levee Subvention Program. The goal of this program, as revised by Delta Flood Protection Act of 1988, is to rehabilitate the local Delta levees to the Bulletin 192-82 standard. There is sufficient flexibility in the Delta Flood Protection Act of 1988 to rehabilitate levees to other federal or local standards as may meet the needs of the local agency with jurisdiction over these levees. Some of the existing or proposed levee standards are shown in Figure 6-1.

To avoid delays in the annual disbursement of funds from the subventions program, the following provisions of SB 34 are being implemented in three stages:

- increase in funding from $2 million to $6 million;
- increase in State reimbursement ratio from 50 percent to 75 percent;
- provision for advances;
- provision for reimbursement or disaster-related work denied by the Federal Emergency Management Agency (FEMA);
- specific review authority by DFG to ensure no net long-term loss of fisheries, riparian, or wildlife habitat;
- competitive bidding and increased documentation requirements resulting from passage of SB 1893;
- funding prioritization plan for years in which "applications for State funding exceed State funds available" to ensure funds are apportioned " . . . among those levees . . . most critical and beneficial, considering the needs of flood control, water quality, recreation, and wildlife." (Quotation taken from SB 34).

The protection act also provides for other flood control measures, such as modification of land management practices, and provides for reimbursement to local public agencies when easements of up to 400 feet wide from the crown of the levees are acquired where DWR determines

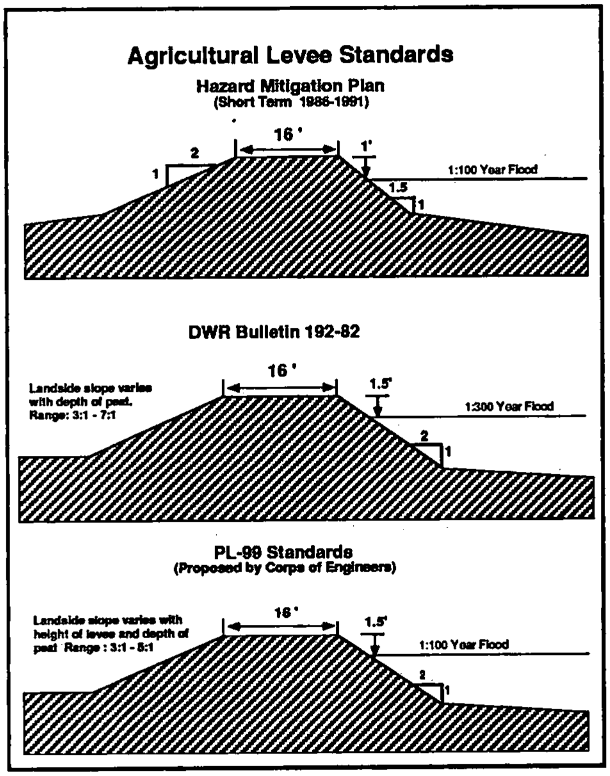


Figure 6–1. Agricultural Levee Standards

it is necessary. Mitigation of wildlife and fisheries habitat is to be determined by DFG.

In addition to the Flood Protection Fund, the bill authorizes $5 million for appropriation by the Legislature to DWR to mitigate specified adverse impacts in the Delta and San Francisco Bay and some other special areas.

SB 34 has the potential to protect water quality in the Delta from salinity encroachment due to island flooding. It will also increase water supply reliability with no net loss of fish and wildlife habitat.

Eight Western Delta Islands – Special Flood Control Project. A report discussing the future implementation of flood control measures for the eight western Delta islands identified in the Delta Flood Protection Act of 1988 is being prepared for the California Water Commission. Scheduled for release by mid-1990, the report will address such topics as:

- comprehensive levee inspections and studies to identify threatening conditions and levee sections that do not meet minimum FEMA flood hazard mitigation standards;

- assistance programs to participate in pilot programs and document the feasibility of using dredged material for levee improvements;

- programs to assist Bethel Island Municipal Improvement District and Contra Costa County in resolving levee encroachment problems according to local guidelines on Bethel Island and Hotchkiss Tract;

- funding of surveys and monitoring to document elevations and subsidence;

- discussions with DFG and land owners to identify options for acquisition of easements and wildlife management areas that provide land use options to reduce subsidence. These discussions will include recreational opportunities; and

- Specific recommendations for "fast-track" levee improvements based on a priority of actions applicable to any of the eight islands. These recommendations would be contingent on environmental requirements.

Program priorities will be evaluated in connection with two categories. One category will be priority of actions. These actions would be designed to apply to any of the eight western Delta islands and include fast-track protective measures. Coordination efforts are under way with local representatives to identify threatening levee situations and levees that do not meet short-term FEMA flood hazard mitigation standards.

A second category will investigate island priorities. One promising high-priority program is Sherman Island. Current planning for this island investigates land use options to reduce subsidence. Reducing subsidence will be a very important aspect of special flood control projects planning to identify options that will provide the highest levels of future flood protection.

A workshop on the 1988-89 subvention program attended by reclamation district(s) trustees, engineers, and attorneys was held recently. Topics discussed included definition of SB-1893 (Competitive Bidding Act) procedures, DFG criteria for ensuring no net long-term loss of habitat, possible yearly carryover of funds, and easement acquisition as defined in SB 34.

Port of Oakland Dredged Material. DWR is working closely with San Francisco Bay Area Regional Water Quality Control Board (Regional Board) to assist in the evaluation of the proposed use of Port of Oakland dredged material for levee improvements. DWR staff has been made available to help define the interrelationships between the proposal and Delta water quality. Staff plans to assist by providing modeling studies of pollutant dispersion, funding for additional sampling, and a literature search of metal stability in soils. DWR is also exploring the possibility of working with the Regional Board, the Port of Oakland project coordinator, and Delta reclamation districts to implement a pilot program and monitor water quality to test the effects of placement of material on Twitchell Island.

DWR recognizes that proposals to use dredged material must be thoroughly tested to protect Delta water quality. Protecting Delta water quality is essential since the Delta is the source of drinking water for 16 million people, and the estuary is a unique and valuable resource. Protecting water quality also means protecting islands from flooding. As demonstrated in past flood events, water quality impacts can be significant to all Delta beneficial uses. Island floodings can cause short- and long-term impacts that decrease the effectiveness of fresh water outflow and allow salt water to travel farther into the Delta. During past flood events, chloride levels reached 440 PPM at the Contra Costa Canal intake. SWP exports were also interrupted and additional salts were exported to State water users, with undetermined consequences. Future flood protection will be expensive and a program for use of dredged materials for levee rehabilitation can greatly reduce costs.

Coordination With Delta Legislation

Recently enacted water-related bills that could provide mitigation, reduce demands, or otherwise affect the Delta are discussed below:

- The federal Disaster Assistance Act of 1988, which provides assistance for people and businesses affected by drought throughout the U.S. The act authorizes the Secretary of the Interior to: 1) perform water conservation and augmentation studies and assist willing buyers and sellers of water; 2) make water or canal capacity available to water users and others; and 3) make loans to water users for management, conservation, or acquisition and transportation of water.

- The act also authorizes a specific program for Oakdale and South San Joaquin Irrigation districts, as well as construction of a temperature control curtain at Shasta Dam for anadromous fishery protection and enhancement.

- SB 795, PL 100-675: Settles a lawsuit in San Diego County over water rights to the San Luis Rey River.

Among many other items, including lining the All-American Canal, the act provides for up to 16 TAF of supplemental water per year. The water will be derived from: 1) water saved by lining the All American Canal, 2) MWD, or 3) public lands.

- SB 2261, Chapter 1545 of 1988: Permits temporary changes involving the amount of water consumptively used or stored, and permits approval by SWRCB of a petition for a long-term transfer of water or water rights, if SWRCB has approved a temporary change.
- SB 2261, Chapter 1545 of 1988: Enacts the Salmon, Steelhead Trout, And Anadromous Fisheries Program Act, which requires DFG to prepare and maintain a detailed conservation program for protection and increase of salmon, steelhead trout, and anadromous fisheries.
- AB 3654, Chapter 1488 of 1988: Requires the Reclamation Board to offer to lease to DFG, or to a public entity, any lands it acquires as replacement habitat to mitigate environmental impacts of its projects. The board is also required to prepare, in consultation with DFG, a mitigation plan to be implemented prior to construction of a flood control, channel clearing, or bank stabilization project.
- AJR 67, Chapter R-151 of 1988: Advises Congress that the legislature continues to support construction of a multipurpose Auburn Dam at the Auburn site.
- SJR 30, Chapter R-123 of 1988: Memorializes Congress to transfer control and operation of the CVP to the State of California or other public entity.

Delta Recreational Planning

The Delta is a major recreational area with many valuable and unique assets. Recreational development is spread throughout the Delta and can be classified as private (over 20 yacht clubs), commercial (over 100 marinas, valued at least $100 million), and public facilities. To date, there are 22 public recreational areas in the Delta, comprising 5,450 acres of fishing access sites, park and recreational sites, hunting areas, and boat launch areas.

Although the Delta has many recreational opportunities, many areas can be improved. Nearly all recreational facilities in the Delta are provided by private enterprise, which caters almost exclusively to boaters. Poor access and few facilities have so constrained use that demand considerably exceeds current use. For example, in 1980, actual use in the Delta was 12.3 million recreation days and the projected demand, if sufficient facilities could be provided, could exceed 21 million recreation-days annually. This results in a latent (or unsatisfied) demand of nearly 9 million recreation-days, which is expected to grow to over 25 million recreation-days if present trends continue.

Public agencies have allocated over $1 million to major reports on Delta recreational planning. A 1958 DWR report, *Sacramento-San Joaquin Delta, Master Plan for Recreation*, discussed the earliest plan for Delta recreation. In June 1966, the Resources Agency issued a preliminary edition of the *Sacramento-San Joaquin Delta Master Recreation Plan*. This report, which was updated in 1973 and 1976, was prepared by representatives of several State organizations. Specific recreational plans have since been developed by all State and local agencies with interests in recreation in the Delta. These specific plans have incorporated many of the ideas contained in the master plan. Funding is the primary problem in implementing most of these plans. Other plans, such as the extensive DWR plans for recreation and fish and wildlife improvements, are associated with the Davis-Dolwig Act and are tied to water development projects.

The Delta Master Recreation Plan occupies a 10-year span in the history of Delta recreational planning, which was updated or revised three times over this period. A major component of the plan, which was also included in several other plans, is the Delta Waterways Use Program. This program recommends an area use-classification system based on an area's natural or ecological value. It also recognizes multiple-use areas, which are designed to accommodate more intensified use (such as water transfer and recreational facilities). Recreational planning following development of the Delta Master Recreation Plan emphasizes integrating recreational planning into a levee rehabilitation strategy.

Given current economic and political conditions, it seems unlikely that a major comprehensive recreational plan could be implemented on its own merits. However, such a plan could provide an economic advantage to an overall levee rehabilitation program (assuming such a plan itself could be implemented). In addition, more focused recreational planning under Davis-Dolwig could also benefit any specific Delta water transfer plan.

Delta Wetlands Project

A unique wetlands management and water storage project for the Sacramento-San Joaquin Delta has been proposed by Bedford Properties, a land development company.

Land use on four Delta islands—Bouldin, Webb, Holland, and Bacon—will be converted from agricultural use to provide waterfowl habitat and to store water during winter and spring. The water for storage will be pumped from the islands in early summer to provide fishery benefits and for use by DWR. The project will undergo a rigorous approval process starting with applications for water rights permits.

The Bedford Properties proposal is being evaluated by DFG and DWR. Both agencies have set up task forces and are working with the project sponsor to define issues and to identify the types of information needed to make decisions about the project. Some of the issues are:

- environmental documentation under CEQA and NEPA,
- required permits,
- Safety of Dams jurisdiction,
- operation, structural engineering, and economic feasibility,
- liability,
- potential regulatory changes,
- control of the water in the reservoir,
- water quality, and
- public perception.

The project has the potential to increase Delta exports and decrease Delta outflows during the winter. The project's main benefit is to provide operational flexibility, which can benefit fish and wildlife and water quality.

Offstream Storage South of the Delta

In 1984, DWR completed a reconnaissance study of 13 potential offstream storage sites south of the Delta. Reservoirs at these sites could be used to store excess runoff pumped from the Delta during wet periods and delivered via the California Aqueduct. The subsequent report *Alternative Plans for Offstream Storage South of the Delta* recommended that future studies focus on the LBG site, south of the existing San Luis Reservoir.

Any new offstream facility south of the Delta would be of little value without the capability of filling that facility during periods of surplus Delta outflow. The planned NDP would provide the capacity to maximize winter banking south of the Delta in a facility such as LBG.

Los Banos Grandes Reservoir. DWR is studying several separate formulations for LBG. The basic formulation would be solely an SWP water supply facility; power generated incidental to the water-supply operation would be incorporated into the SWP power resource plan. Other formulations under study include:

- a joint SWP/CVP facility with incidental power incorporated into the SWP and CVP resource plans; and
- a SWP water supply facility with participation by a private power utility in pumped-storage power generation facilities.

Planning will concentrate on project formulation, analysis of water and power operations, exploration of possible Reclamation and/or utility participation, and development of mitigation plans to offset fish and wildlife impacts. The principal environmental issues appear to be 1) the inundation of significant riparian habitat along Los Banos Creek, and 2) impacts on the San Joaquin kit fox, a species listed as 'threatened' by the State and 'endangered' by the federal government.

The revised schedule calls for completion of the draft EIR/EIS by mid-June 1990 and the final EIR/EIS in June 1991. With this optimistic schedule, the LBG facilities could be completed and in operation by mid-2002.

LBG will provide operational flexibility for the SWP. Operational flexibility will provide improved SWP operations for the fishery and enable shifting more exports to winter and high-flow months, when fish are not as abundant.

Surface and ground water storage south of the Delta will increase exports in wetter years and will cause minimum impact in drier years. Delta outflow will be reduced in wetter years, and water quality will be slightly changed during winter months. The storage projects will provide operational flexibility to reduce incremental fish screening losses.

Kellogg/Los Vaqueros Reservoirs. In fall 1985, Reclamation expanded its Kellogg Reformulation Study to include a preliminary analysis of the Los Vaqueros Reservoir site. The study previously concentrated on Kellogg Reservoir and relocation of the Contra Costa Canal intake. Reclamation's planning report and draft EIS were available for review in early 1988. The report indicated that the High-line Canal and relocation of the Contra Costa Water District intake to Clifton Court are the best alternatives.

Contra Costa Water District (CCWD) began purchasing the entire Kellogg/Los Vaqueros watershed in early 1987. Environmental and land management plans were addressed by Jones and Stokes, the district's environmental consultant, during 1987 and 1988. A Stage II EIR/EIS will be completed by spring 1991. DWR has paralleled CCWD's studies with operations and cost studies needed to determine whether participation is desirable. However, SWP cannot participate in Los Vaqueros because of the language approved by the electorate in a recent bond authorization initiative

Kern Water Bank

The KWB program is a proposed conjunctive use ground water program being developed by DWR, in cooperation with KCWA and local water districts, to augment the dependable water supply of SWP. This program would allow KWB to store and extract water from the Kern County Ground Water Basin, in coordination with the operation of surface water storage and conveyance facilities. In general, water would be banked in the basin during years of above-average water supply and withdrawn during drier years, when surface water supplies are below average.

KWB is being developed as individual "elements," or components, of an overall water recharge, storage, and extraction program of SWP in the Kern County Ground Water Basin. The Kern Fan Element is a program of direct recharge and extraction on 20,000 acres along the Kern River alluvial fan, west of Bakersfield and adjacent to the California Aqueduct. DWR purchased the land in 1988. Additional "local elements" will be developed as cooperative programs with surrounding water districts. These local elements will be combinations of in-lieu and direct recharge programs. In wetter years, in-lieu programs will provide additional water to local farmers in return for reduced surface water deliveries in drier years. Such programs will generally involve expansion of surface water distribution systems to deliver additional water in wetter years and construction of additional wells to increase pumping capacity in dry years.

During 1989, the Kern Fan Element program was restructured for staged development. Initial plans called for development of a program with maximum storage of 1 MAF, with the first stage planned for maximum storage of 300 TAF. The first stage is planned for development beginning in 1991, and ultimate development following in 3 to 4 years.

Local elements will also be developed in stages. As of December 1989, one local element was being studied at the feasibility level, and four others were being studied at the reconnaissance level.

The Kern Fan Element has the potential of increasing SWP firm dry-period yield as much as 140 TAF. Initial studies indicate that local elements could more than double the contribution of KWB to SWP supplies.

The project will increase exports and decrease outflow during wetter years, but will have no effect on inflow. It will provide operational flexibility to reduce incremental fish screening losses and only slightly degrade water quality.

North Of Delta Additional Storage Development

The most economical dam sites in California have already been developed. For environmental, economic, or financial reasons, some reservoir projects once seriously considered for construction have been deferred. Surface storage facilities north of the Delta are discussed in the following paragraphs.

Shasta Lake Enlargement. In recent years, Reclamation and DWR have studied the feasibility of enlarging Shasta Dam. One alternative studied was to increase the height of the existing dam by 200 feet, which would enlarge the reservoir's storage capacity from the present 4.5 MAF to 14 MAF and increase the dependable water supply by about 1.4 MAF per year. Although the unit cost of water would be relatively low, the capital cost would be substantial. Therefore, California's water interests have concluded that other needs take priority over the additional storage of an enlarged Shasta Lake.

These needs include developing more offstream storage south of the Delta, solving San Joaquin Valley drainage problems, and planning the expansion of the CVP aqueduct system of the San Joaquin Valley (the Mid-Valley Canal). As a result, Reclamation shifted its planning emphasis toward conveying and protecting the quality of existing supplies before developing new supplies. DWR, responding to growing recognition among water contractors of increasing project costs, shifted its planning to smaller, less expensive projects.

Marysville Dam and Reservoir. Marysville Reservoir on the Yuba River, originally authorized as a Corps project in the

1960s, was not developed. The proposal was reanalyzed in 1982 as a possible local project of the Yuba County Water Agency in partnership with KCWA. Neither proposal went beyond the planning stage.

Later, DWR investigated a multipurpose project to provide power, flood control, and additional conservation yield for the SWP, by using the Corps plan for the Parks Bar and Dry Creek Dam sites (about 5 miles upstream of the city of Marysville) and updating the construction cost estimates. Because of the apparent high unit cost of water from the project and the lack of local support, the proposal is currently inactive.

Glenn Reservoir Project. During the 1960s and 1970s, the State studied various possibilities for developing storage reservoirs on Thomes Creek and Stony Creek on the west side of the Sacramento Valley. Three different reservoir sites were considered for various sizes, combinations, and configurations. These were the Paskenta, Newville, and Glenn reservoirs. Under one routing of Eel River imports, the reservoir(s) would have been used to store water from the North Coast. With the slowdown in agricultural demands, and the prospect of more favorable alternatives, planning for these projects has been deferred indefinitely.

Eel River Exports. The 1973 California Wild and Scenic Rivers Act precluded development of many of the North Coast's major streams. The act also provided that DWR, after an initial 12-year period, would report on the need for water supply and flood control projects on the Eel River and its tributaries.

On August 30, 1985, DWR reported by letter to the Legislature:

> "... Based upon the situation today, we see no reason to seek legislation to withdraw the Eel River from the Wild and Scenic River's System ... it is our view that we would not look to the Eel River as a practical source of additional water supply within the near future, irrespective of its wild and scenic status. It seems appropriate to leave the Eel in the Wild and Scenic River system, subject to future review and reconsideration."

Red Bank Project. Cottonwood Creek, in Shasta and Tehama counties, is the largest uncontrolled tributary of the Sacramento River and is a major contributor to flooding, particularly along the upper river. In the mid-1960s, the Corps selected the Cottonwood Creek Project as the most suitable means of providing flood protection and developing additional water supply.

A 1984 engineering report estimated the total first cost of the Cottonwood Creek Project at $753 million. The annual payments by the SWP contractors would have been prohibitively high. Consequently, in June 1984, DWR asked the Corps to reanalyze the project, looking at methods for cost reduction. The Corps' reanalysis reduced the total first cost to $571 million.

After discussions with the SWP contractors and a briefing before the California Water Commission in 1985, DWR decided not to participate in the project.

In June 1985, DWR's Northern District published a memorandum report, which recommends studying construction of a combination diversion and storage dam at the Dippingvat site on South Fork Cottonwood Creek, a storage dam at the Schoenfield site in the adjacent Red Bank Creek Basin, and a conveyance system connecting the two reservoirs.

Following the June 1985 report's recommendations, DWR began a two-year prefeasibility investigation of the Dippingvat-Schoenfield Project. The cost, including interest during construction and the present worth of operation, maintenance, and replacement, was estimated at $119 million. The project would provide a critical period water supply of 47 TAF/YR to the SWP, assuming Delta transfer facilities are in place. The cost allocated to municipal and industrial water supply would result in a unit economic cost that is competitive with other sources of water supply now under consideration.

The Dippingvat-Schoenfield Project would reduce the 100-year peak flood flow at Cottonwood from 106,000 cfs to 90,000 cfs. The project initially would provide up to 9,000 public recreational days per year, increasing to an estimated 113,000 days per year by the end of the 50-year analysis period.

Following the November 1987 report's recommendation, DWR began a feasibility study of the Dippingvat-Schoenfield Project, now called the Red Bank Project, to be completed by mid-1990. The study—being conducted in cooperation with Reclamation, DFG, USFWS, and the Corps—will include fishery and flood control elements. Communication with Shasta and Tehama counties and cooperative agencies is maintained through an advisory group.

Auburn Dam and Reservoir. In 1967, Reclamation began preliminary construction activities for a 685-foot-high concrete arch dam at the Auburn site. The dam would have impounded a 2.3 MAF multipurpose reservoir to provide CVP water supply, power, recreation, flood control, and fishery enhancement. After foundation preparation was completed in 1976, construction was suspended to permit further study of seismic and design issues.

After intensive studies by eminent engineers, geologists, and seismologists, the Secretary of the Interior concluded in 1980 that a safe dam could be constructed. A concrete gravity dam was recommended in lieu of the original thin arch design, but final design was deferred pending resolution of questions about flows in the lower American River.

Meanwhile, the Corps has continued reconnaissance level studies of flood control options for the lower American River area. Considerable support has come from the Sacramento Area Flood Control Agency in a February 1990 resolution calling for a flood-control only dam at Auburn, which could be expanded when water, power, and recreational interests are able to finance the enlargement.

Folsom Dam and Reservoir–Folsom South Canal. Whereas this is not a new project, there has been a resolution of a long-standing problem involving a storage contract between EBMUD and Reclamation, versus a group of interested users of lower American River flows. EBMUD will be able to exercise its contract with Reclamation for 150 TAF of Folsom storage annually and to take this water through the Folsom South Canal. A connection will be built by EBMUD between the end of the Folsom South Canal and the Mokelumne Aqueduct. In turn, EBMUD will be restricted by a diversion schedule that helps keep the lower American River in a healthy condition.

Additional storage north of the Delta will potentially increase summer and fall inflow, decrease winter and spring inflow, increase drier year export, reduce winter and spring outflow, and increase summer and fall outflow. Other potential effects include drier year water quality protection, increased river flows, and increased fish screening losses.

Central Coastal Studies

At the request of San Luis Obispo and Santa Barbara County Flood Control and Water Conservation districts, DWR is conducting advanced planning studies, including preparation of an EIR for the proposed Phase II of the Coastal Aqueduct. The Coastal Aqueduct will furnish between 52,973 AF/YR and 82 TAF/YR, depending on Santa Barbara County's decision to obtain part of its entitlement from the proposed Enlarged Lake Cachuma project, providing it wants to re-purchase the 12,214 AF of SWP water relinquished in 1981. Annual entitlement of SWP water is 25 TAF for San Luis Obispo County and between 45,486 and 57,700 AF for Santa Barbara County.

Santa Barbara County will have to develop local distribution facilities to convey their SWP water entitlement from the terminus of the Coastal Aqueduct to areas of need. One such local facility, the Mission Hills Extension, will transport water to northern communities of the county and terminate near the city of Lompoc. Another local distribution facility, the Santa Ynez Extension, would extend service to the upper Santa Ynez Valley and South Coast communities.

At the request of Santa Barbara County Flood Control and Water Conservation District, DWR is conducting the environmental assessment and reconnaissance level design for the Extension as part of the advance planning study of the Coastal Aqueduct. Costs of the Santa Ynez Extension have been estimated for economic analysis only.

Phase II, 87 miles long, starts at Devils Den in the northwest corner of Kern County and proceeds southwest of San Luis Obispo, then south to the Santa Maria River. The pipeline varies in diameter from 60 inches at Devils Den to 54 inches at the Santa Maria River. Three pumping plants will lift the water over the Temblor Mountain range near Polonio Pass. The water will then flow by gravity to the Santa Maria turnout. A power recovery plant near San Luis Obispo will be used to reduce the pressure in the pipeline. There will be four water storage tank sites at Polonio Pass, northeast of Santa Margarita, east of San Luis Obispo, and just east of Arroyo Grande.

The Mission Hills Extension, 23 miles long, starts at the Santa Maria River and proceeds south to Mission Hills near Lompoc. The extension pipeline connects with the Phase II pipeline at the Santa Maria River. The extension pipeline varies in diameter from 54 inches at the Santa Maria River to 39 inches at Mission Hills. A pumping plant two miles north of Casmalia will lift the water over the Casmalia Hills. One water storage tank site will be located one mile south of Casmalia, and another will be at Mission Hills.

DWR's environmental study teams (botanists, wildlife biologists, and archaeologists) have been conducting onsite field surveys along the proposed pipeline alignment.

The teams have been recommending slight adjustments in the alignment within the study corridor to avoid sensitive habitat. DWR staff members have also conducted meetings and field surveys with the Corps, USFWS, and DFG representatives to discuss Section 404 permit requirements and to gather recommendations for minimizing project impacts. DWR staff also had five meetings with landowners to discuss alignment of the Aqueduct.

Phase II of the Coastal Aqueduct has the potential to increase SWP deficiencies slightly. Because export, inflow, and outflow are not affected by the project, no cumulative impact will result from the NDP.

In addition, Reclamation and DWR are conducting a joint study of the feasibility of enlarging Cachuma Reservoir (Bradbury Dam) in Santa Barbara for additional water supply for the SWP. If constructed, this would be the first local project incorporated as part of the SWP. Also, Reclamation is evaluating ways to bring Bradbury Dam into compliance with its safety of dams criteria.

The reservoir has a storage capacity of 205 TAF and a firm yield of 24 TAF for recreation, irrigation, municipal, and industrial uses. Water is released for these demands through: 1) a river outlet for downstream releases; 2) a pipeline for the Santa Ynez River Water Conservation District, Improvement District No. 1; and 3) Tecolote Tunnel for the Santa Barbara area. The preferred enlargement will increase storage some 197 TAF and would provide the SWP a safe yield of 17 TAF/YR when combined with vegetation management and cloud seeding programs.

Through a contract with Reclamation, an environmental consultant has prepared a preliminary mitigation plan for the potential impacts of the enlarged Cachuma project. As expected, the key mitigation issues will be loss of riparian and wetland habitat, loss of oak/woodland habitat, and impacts to the steelhead fishery.

Potential Conjunctive Use Programs

Conjunctive use is a planned use of both surface and ground water in a complementary manner to increase water yield and/or reliance. Conjunctive use programs will generally reduce pressure on Delta exports, manage resources more efficiently, and increase yield to existing projects.

New Melones Conjunctive Use Plan. Two San Joaquin County Agencies, Stockton East Water District and Central San Joaquin Water Conservation District, made a proposal to DWR that could increase the yield of the SWP. These two districts have contracts with Reclamation for 155 TAF (106 TAF surplus and 49 TAF firm) of New Melones Project water. The districts propose to use their contract entitlements in normal and above-normal years but forego diversions during dry and critical years and release the water down the Stanislaus River into the Sacramento–San Joaquin Delta. The districts would rely on ground water to meet their needs during dry and critical years and then recharge their basins during normal to wet years. In turn, they would want financing for the necessary facilities to divert and convey the New Melones water to their service areas. The proposal has been discussed with Reclamation—which owns and operates New Melones—with San Joaquin County interests, and with the State water contractors. These discussions indicate that the proposal has merit, and DWR plans to use the environmental documentation process to investigate its feasibility.

DWR and Reclamation see the proposal as having the potential to provide many benefits, including water supplies for local use, increased fishery flows in the Stanislaus and San Joaquin rivers, improved water quality in the south Delta, and increased yield to the both SWP and CVP. To attain these benefits, all parties involved must be included in the planning process. Since Reclamation owns and operates New Melones Reservoir, it is a key participant in the program.

In March 1989, DWR and Reclamation signed a Memorandum of Understanding with 15 agencies in Calaveras, Tuolumne, Stanislaus, and San Joaquin counties to prepare a plan for the long-term use of water supplies from the Stanislaus and Calaveras rivers. DWR and Reclamation have developed and completed a "Scope of Study" for the program and will issue a Preparation/Notice of Intent to prepare a Draft EIR/EIS for the Stanislaus River Basin and the Calaveras River Water Use Program.

Glenn–Colusa Irrigation District – DWR Contract. In late 1988, DWR entered into an agreement with Glenn–Colusa Irrigation District to perform a cooperative ground water investigation. Past studies indicate it is possible and may be economically feasible to develop a well field. The investigation evaluates the impact and economic considerations of developing the ground water.

The Glenn–Colusa Irrigation District has drilled a test well to determine the feasibility of supplementing the surface water supply with ground water. DWR is funding 50 percent of this project. The district wishes to develop a conjunctive use operation to ensure its users a reliable supply during water shortages. They would like to develop a ground water capacity of about 100 TAF/YR. The district testing program has been successful, and a production well yielding some 3,000 gpm has been completed. The next phase of the investigation is now being planned.

Potential Water Conservation Alternatives

The ethic of conserving water has been woven through law and practice in California for decades. It can be traced back to a 1928 Constitutional Amendment, which was adopted to ensure the reasonable and beneficial use and the prevention of waste and unreasonable use of water.

The 1976–77 drought demonstrated, sometimes dramatically, that people can reduce water use when an emergency requires it. This experience, coupled with the growing cost of major water project development, has led to an array of water conservation programs at the State and local government level.

Water management plans for urban areas will benefit both project operations and contractors by reducing demand buildup schedules, thereby stretching available supplies and reducing risks of water shortages. The reduced demand buildup schedule would minimize potential Delta export impacts.

The two most recent significant pieces of legislation are the Urban Water Management Planning Act of 1983 and the Agricultural Water Management Planning Act of 1986. Both require the larger water suppliers, under certain conditions, to prepare water management plans.

Urban Conservation. Some 300 urban water suppliers have prepared water management plans under the Urban Water Management Planning Act of 1983. These plans identify many current and future water conservation programs. They include low water–use landscaping and improved irrigation efficiency on large turf areas, water audits and leak detection, industrial water conservation, residential retrofit with low–flow and ultra–low–flow toilets and showerheads, waste water reclamation, capital outlay projects to replace old water mains and similar facilities, public education, and in–school education. DWR has provided technical and financial assistance to urban water agencies and local governments in all these areas since 1980.

Agricultural Water Conservation. California's agricultural sector has for decades been developing and implementing ways to reduce onfarm water use. This conservation effort has been broad–based, involving various public institutions, private industries, and individual farmers. Year by year, on a continuing basis, many different irrigation techniques have been developed to reduce and tailor water use for the varied irrigation conditions encountered throughout the State.

DWR has had a multifaceted agricultural water conservation program since 1980. It focuses on assisting water districts and growers with irrigation scheduling based on crop water needs, education to improve the efficiency of various irrigation systems, support of research related to improved irrigation management and reductions in evapotranspiration rates of crops, and financial assistance to agricultural water districts to begin or expand their irrigation management programs.

Since the mid–1970s, DWR has published estimates of weekly crop water use—information that many farmers have used to schedule irrigations. The estimates are based on measured rates of evaporation from standard National Weather Service evaporation pans installed at selected sites within some of the major irrigated areas of California. Now, in response to the need for real–time evapotranspiration information, daily estimates of crop water use are available through the California Irrigation Management Information System, a large, automated weather station network that records solar radiation, wind speed, rainfall, air temperature, humidity, and soil temperature.

These data are transmitted daily by telephone to a central computer that calculates how much water certain plants in a certain area would have used under specified conditions for such factors as soil moisture availability and plant growth. The results are then made available to farmers and other interested parties, who access them through personal computers. The information is also available through irrigation consultants, county farm advisors, U.S. Soil Conservation Service (SCS) field offices, and the media.

While crop water use estimates help farmers decide when to irrigate and how much water to apply, mobile irrigation management laboratories are also available to measure how efficiently an irrigation system is working. These labs are operated by local resource conservation districts, with technical support from SCS.

In 1986, the Legislature passed the Agricultural Water Management Planning Act. It required every agricultural water retailer supplying more than 50 TAF of water, if not covered by water conservation requirements of State and federal agencies, to report to DWR on how its water is managed. If the supplier finds that water can be conserved, or that the quantity of highly saline or toxic drainage water can be reduced, the supplier must adopt an agricultural water management plan.

Industrial Water Conservation. Under a contract with DWR, MWD completed a literature search to identify industrial water conservation technologies. The best of the abstracts have been reprinted and made available to local water districts for distribution to industrial customers.

DWR is also cosponsoring a project with the City of San Jose. The city's consultant will visit selected industries to assess their potential for improving their water use efficiency. Follow-up pilot projects will be undertaken for those industries showing potential.

Water Transfers

Statewide emphasis on several distinct types of water transfers has intensified during the 1980s. A number of new laws have been passed that express State policy, add to the existing water rights authority of SWRCB, and authorize new programs for DWR. These include:

- Voluntary transfer of water and water rights is advocated, where consistent with the public welfare of the place of export and the place of import.
- DWR and SWRCB are directed to encourage voluntary transfers of water and water rights by offering technical assistance, if necessary, to identify and implement water conservation measures that will make additional water available for transfer.
- Local and regional public agencies are authorized to sell, lease, exchange, or transfer surplus agency water for use outside the agency.
- State and local agencies are prohibited from denying a bona fide transferrer of water the use of unused capacity in a water conveyance facility.

DWR is required to:

- establish an ongoing program to facilitate the voluntary exchange or transfer of water;
- implement various State laws pertaining to water transfers;
- create and maintain a list of entities seeking to enter into transfers and a list of the physical facilities that may be available to carry out water transfers; and
- prepare a water transfer guide.

Water transfers can increase Delta inflow and outflow in drier years, increase exports when transfers are north of the Delta, and decrease exports when transfers are south of the Delta. Water quality will be improved, although fish screening losses will be increased.

In March 1986, DWR established an in-house Water Transfers Committee to respond to the interest in water marketing and water transfers. The committee has published two documents to facilitate the voluntary exchange or transfer of water within California. They are titled *A Catalog of Water Transfer Proposals* and *Questions to be Asked in the Case by Case Review of Water Transfer Proposals.* A draft *Water Transfer Guide,* authorized by Section 482 of the Water Code was released in June 1989.

Ideally, a market system involving transfer of water should improve the lot of both the buyer and seller. The buyer should gain by acquiring water needed at a favorable cost; the seller should gain by receiving more in return than he would gain by keeping the water. However, there is concern that such transactions may not adequately compensate those not directly involved in the buying and selling process (farm laborers, food processors, and retailers, for example).

Market water transfers can realize efficiencies; however, equity questions can arise, including instream uses, waster rights questions, third-party impacts, and adverse economic and environmental effects.

Questions are also being raised over whether a market concept would really result in the highest and best use of the water resource. It may be more a sign of comparative purchasing power among sectors than an optimum use pattern. The urban sector, for example, could probably outbid agriculture for a given water supply, but water used to irrigate lawns or wash cars could be regarded as having less economic and social value than water used to produce food.

To date, it appears that a true "market" is unlikely to evolve on a statewide basis in California. However, the fact that water managers and water constituent groups have begun to think in "market" terms has already led to numerous innovate suggestions for water transfers and water sharing.

Transfer of SWP Entitlements. In March 1987, the California Water Commission sponsored a "Briefing and Discussion of Transfer of SWP Entitlements" in Bakersfield. The Commission heard statements from representatives of various SWP contractors. Some of the contractors would like to sell their entitlements, others would like to purchase entitlements, and still others support the concept of the SWP buying back entitlements.

CVP Purchases. DWR has an interest in purchasing existing CVP water supplies that CVP will not need for at least 10 to 20 years. DWR is interested in acquiring such interim supplies to meet near-term SWP needs.

The COA provides that Reclamation and DWR will negotiate a contract for the sale of interim federal water to DWR and for conveyance of federal water through SWP aqueduct facilities. SWRCB, DFG, and USFWS are also involved in the negotiations, which are open to the public. The negotiations are closely coordinated with periodic meetings with the State water contractors. (See also "Wheeling-Purchase Negotiations" in Section 10 (h) of the COA, page 173.

Yuba County Water Agency. DWR entered into an agreement with the Yuba County Water Agency (YCWA) to purchase water released from New Bullards Bar Reservoir during the summer of 1988. The release of this water by YCWA allowed DWR to hold a corresponding amount of water in Lake Oroville and had the effect of transferring the water from New Bullards Bar Reservoir to Lake Oroville.

DWR and YCWA re-negotiated a water transfer for 1989. Yuba County agreed to make 200 TAF of water available. Santa Clara Valley Water District paid the costs of transferring 90 TAF, and Tulare Lake Basin Water Storage District paid the costs of transferring the remaining 110 TAF.

Discussions concerning another transfer in 1990 have been proceeding informally.

City of Napa. The city purchased 7 TAF of water from YCWA for use in 1989. The water was conveyed through the North Bay Aqueduct (NBA).

East Bay Municipal Utility District. Water rationing was instituted in 1988 and had been planned for 1989, at the 25 percent level. The East Bay Municipal Utility District (EBMUD). EBMUD purchased 60 TAF of water from the YCWA to avoid rationing at greater than 25 percent. As a result of additional rains, however, EBMUD did not use this water. In August 1989, EBMUD sold 30 TAF of the purchased water to DFG for use in the San Joaquin Valley for salmon enhancement and riparian use. The City of Napa and EBMUD negotiated directly with Yuba County Water Agency for their purchases.

Marin Municipal Water District. Marin Municipal Water District (MMWD) is seeking a supplemental water supply of 10 TAF per year, with the NBA as a possible link in the delivery chain. Water purchased by MMWD somewhere in the Central Valley could be rediverted from the Delta into the NBA and delivered at NBA terminal facilities. MMWD would have to build a conduit from the NBA to its service area in Marin County.

DWR has participated in meetings with MMWD and representatives of the Napa and Solano County agencies that have contracted for deliveries from the NBA. These meetings were primarily to allow MMWD to present its tentative plans to NBA users and assure them that if its use of the NBA should prove feasible, it intends to negotiate mutually beneficial agreements for that use.

Technology For Increasing Water Supply

The following sections describe the present situation regarding augmentation of water supplies by various technological approaches.

Watershed Management. Watershed management can protect developed supplies by reducing sediment accumulation in reservoirs and increasing streamflow by managing vegetative growth. Reducing the amount of shrub and tree cover and substituting grasses both reduces vegetative water use and increases runoff. Water supplies may be augmented where reservoirs regulate the increased runoff.

Water supplies gained by such means, although small in relation to total runoff, can cost less than supplies developed by building new reservoirs. However, extensive areas would have to be managed to significantly increase statewide water supplies. Vegetation management is now being used principally to improve range, reduce wildfires, and enhance wildlife habitat.

Watershed management upstream of the Delta can increase Delta inflow and increase drier year export and outflow. The technique can improve water quality protection in drier years and increase river flows while increasing screening losses.

Weather Modification. Research has established that rain and snow from clouds with the right moisture and temperature characteristics can be increased by weather modification. Many investigators believe that average annual precipitation might be increased by about 10 percent. Weather modification has been conducted along the western slopes of the Sierra Nevada and some of the Coast Ranges for several years. However, precipitation will increase only when storm clouds are present, which means that the technique is more successful in years of near-normal rainfall. Weather modification is most effective when combined with vegetation management to prevent shrubs and trees from using the additional precipitation.

In 1985, DWR awarded a contract to North American Weather Consultants to conduct a feasibility study of cloud seeing in the Feather River watershed. The results led to funding the design of an operational plan and preparation of environmental documentation for an inflow enhancement program.

The program emphasizes augmenting streamflow by increasing snowpack. It is being developed from a 3- to 5-year prototype project in a remote area of the Middle Fork Feather River near Johnsville. The final operational plan is being designed and implemented by a weather scientist.

DWR is totally funding the prototype project. DWR will also provide environmental documentation for this program and for possible future expansions.

The prototype project will furnish information to guide future design of a larger cloud seeding program in the Feather River watershed. The final operational project will specify the storms to be seeded, seeding agents to be used and rates of application, locations for ground-based generators, suspension criteria, and proposed method of evaluation.

The program began in October 1988 with issuance of a negative declaration for the prototype runoff-enhancement program. In November 1988, two propane dispensers were installed to permit evaluation of the capabilities of the equipment control system and to provide information on the effectiveness of using propane to enhance precipitation.

If the program proves to be feasible, the eventual average yield might approach 100 TAF for a 50-dispenser operation program.

Upstream weather modification can increase Delta inflow and increase drier year export and outflow. It can improve water quality protection in drier years and increase river flows while increasing screening losses.

Desalination. The possibility of finding an economical way to desalt ocean water and brackish water has intrigued engineers, politicians, and the public for many years. Much research has been done and, in some parts of the world, desalting is an important source of water. Worldwide, desalting capacity is about 3 billion gallons per day in 3,500 plants. In the United States, about 750 desalting plants have a combined capacity of 212 million gallons per day. In California, desalting is used to reclaim brackish ground water, desalt sea water, and treat water for such industries as the electronics industry, which require process water of high purity.

Unfortunately, it is still too expensive for all but a few places and situations in California. Present desalting processes can remove high percentages of organic and inorganic constituents from water, including sea water. Moreover, fresh water obtained from desalting processes can be tailored (by careful selection of process type and design) to meet the water requirements of almost any beneficial use.

The principal limitation of desalting is its high cost, which is directly linked to its high energy requirements. In California, cost has greatly restricted its use. Of the various desalting techniques, the membrane processes (reverse osmosis and electrodialysis) offer the best potential to further reduce costs and thus increase use. Extensive research is being conducted in the private and public sectors to improve the performance of membranes used to remove salt from water. Future improvements in the various distillation methods of desalting are likely to be less significant than those related to membrane desalting.

The Los Banos Demonstration Desalting Facility in the San Joaquin Valley began operation in late 1983 to investigate the present technology and economics of reclaiming drainage water by desalting. In late 1986, following the San Luis Drain shutdown by the federal government, the plant lost its agricultural feedwater, and, except for the solar pond system, the facility closed down. No results have been reported.

The DWR solar pond system at Los Banos is still operating. The Rankine-cycle power generator has operated for two summers, producing about 10W. A 5,000 gallon-per-day vertical-tube foamy evaporator desalter has been integrated into the system to demonstrate steady-state operation of a salt-gradient, power-generation desalting system.

DWR is cooperating with other agencies to establish a multiagency treatment center for investigating selenium-specific removal technologies and evaporation ponds. This treatment center would be located at Westland Water District's Tranquility site. Additional desalting pretreatment studies by DWR could be conducted at this site.

In California, desalting technology is being studied or used in the following situations:

- Reverse osmosis and electrodialysis membrane desalting of brackish ground water can be used to supply drinking water. This may or may not be related to the brackish nature of the water but may instead be a case in which a particular constituent (natural or otherwise) must be removed to meet health or other standards. In the Arlington ground water basin in Southern California, a project is in the planning stage to desalt about 6 TAF of local ground water a year; and in Orange County, a 1-million-a gallon-per-day reverse osmosis demonstration plant is being constructed. At both sites, the major water quality concern is high nitrate concentrations in the local ground water, a desalting application that is likely to find wider acceptance as new, more efficient membranes are developed.

- Reverse osmosis can be used to reclaim domestic waste water before it is recharged into ground water basins. The best example of this in California is the Orange County Water District's Water Factory 21, which treats 15 million gallons of waste water a day in an advanced waste water treatment and desalting plant and injects it into the local ground water basin.

- As water pollution standards become more stringent, California industries can use desalting to meet discharge requirements. In the San Joaquin Valley, the olive-processing industry, whose discharges are heavily saline, is studying desalting as a method of reducing waste water and supplementing its process water supplies.

- Throughout the State, many industries use desalting to develop process water required for manufacturing paper, pharmaceuticals, certain foods, and electronic components.

- Finally, sea-water desalting is used at locations such as PGandE's Diablo Canyon Power Plant, where a sea-water reverse osmosis plant provides in-plant water. In the San Joaquin Valley, many agencies have been studying the disposal of brackish agricultural drainage water for decades. DWR has investigated reclamation of agricultural drainage water by reverse osmosis since the early 1970s. Discovery of selenium in this water and the ill effects this element has on aquatic wildlife have increased interest in reclaiming drainage water, rather than discharging it to the ocean or estuary. In California, the potential exists to reclaim several hundred thousand acre-feet of drainage water per year through a combination of desalting, salt-harvesting, and power production from salt-gradient solar ponds. Studies of these activities are continuing.

Although the use of desalting to supplement water supplies will continue to be guided by local circumstances, it is likely to increase as the costs of more conventional water supplies rise and the expense of desalting (particularly reverse osmosis and electrodialysis) decreases.

Desalination south of the Delta has the potential to reduce Delta exports, increase water quality protection, and minimize screening losses.

Waste Water Reclamation. Reclaiming and reusing water can lead to important benefits. Reusing water can defer or eliminate the need to develop new fresh water supplies and conveyance facilities, Reclaiming the water in a satellite treatment plant near the place of use can postpone the enlargement of collection systems and treatment plants. Similarly, reclamation may reduce waste water discharge and defer expansion of ocean outfall systems.

Reclaimed water is used for various purposes, including irrigation, industrial cooling, and ground water recharge. Industrial process water may be recycled to recover heat or materials, save water, and reduce sewage discharge fees.

Waste water can be treated to drinking-water quality; however, reuse for drinking water is not permitted, pending studies to determine the long-term effects of reclaimed water on human health.

Because many potential sites for reuse are often often located far from the point of supply, the need for separate storage facilities and dual distribution systems increase the costs of many reuse projects. Furthermore, users may be expected to pay the full cost of developing a reuse project.

More treated municipal waste water is now produced in California than is being reclaimed, yet water reclamation is increasing. In 1985, about 250 TAF was reclaimed. At present, hundreds of thousands of acre-feet of treated water are discharged to the ocean every year. By 2010, under favorable conditions, statewide use of reclaimed water could reach 500 TAF annually, as urban water managers continue to seek opportunities to use reclaimed water in-lieu of water of drinking quality. The greatest incentives for expanded reuse occur where 1) treated waste discharge is limited by regulation, 2) treatment plant capacity is being exceeded, 3) potable water supplies are being fully used, or 4) potable water is expensive.

Long-Range Weather Forecasting

Accurate advance weather information—extending weeks, months, and even seasons ahead—would be invaluable in planning water operations in all types of years — wet, dry, and normal. Had it been known, for instance, that 1976 and 1977 were to be extremely dry years or that the drought would end in 1977, water operations could have been planned somewhat differently and the impacts of the drought might have been lessened.

The potential benefits of dependable long-range weather forecasts could probably be calculated in hundreds of millions of dollars, possibly even in billions. The value would be national. For this and other reasons, research programs to investigate and develop such forecasting capability would most appropriately be conducted at the national level. The National Weather Service and the Scripps Institute of Oceanography are engaged in making such forecasts. However, their predictions are not sufficiently reliable for project operation.

Global Warming (Greenhouse Effect). In 1988, the issue of global warming was widely publicized by articles in magazines and newspapers and by a series of Congressional hearings. This widespread interest was undoubtedly abetted by the warm summer and the 1988 drought. There was, and still is, a perception by much of the public that "something is wrong with the weather." The greenhouse effect offers a possible, although controversial, explanation.

Any warming trend, whether the greenhouse effect or just part of a long-term trend, could have some of these effects:

- ***Changes in runoff patterns***, with more during the winter and a decrease in snowmelt. Due to snow falling at higher levels during storms, more precipitation would fall in the form of rain-producing direct runoff, and less would be held over until spring as snow. This means less snowmelt runoff and more winter flood runoff.
- This would be of concern since average April-July runoff is about 14 MAF, or about 40 percent of the estimated total statewide net water use of 34 MAF. Loss of one-third of this natural regulation is 3.5 MAF, which then would have to be replaced by new water storage facilities or a reduction in water supply yield.
- ***Sea-level rise.*** The current rate of sea-level rise is probably about 0.7 feet per century along the California coast based on San Diego and San Francisco tide gage records. The rise has been fairly constant during the past 50 years and does not show acceleration. A study conducted by EPA investigated the consequences of a 3.3-foot rise, which would be substantial. However, such a rise probably could not occur until some years after 2050.
- In the Delta, a rise to the higher level would be very significant because of the poor levee systems. Any rise could cause some problems. However a minor rise—an extension of current rates—could be tolerated. A major rise, however, would cause significant problems both in the Delta and along the shores of San Francisco Bay.
- The effect of higher sea levels shows up mostly during storms, when the risk of extremely high tides is increased, and formerly uncommon events become frequent. This could cause a shift in the frequency of extreme events. The rare once-in-100-years event could become a 10-year event. The other effect of a higher sea level is increased salinity intrusion due to increased channel depth. Probably enough silt comes down the Sacramento River system to offset a small rise in sea level in the upper estuary (especially in Suisun Bay). It is suspected that the effects on salinity intrusion would be less than that caused by the deep water ship channels, unless the rise exceeds 1 foot.
- ***Warmer temperatures*** would also affect crop patterns and, thereby, water use. The biggest factor is the potential reduction in frost damage, but warmer temperatures could put added stress on some crops (as well as many of our forests and native plants). These changes would permit expansion of some crops, such

as citrus fruits. There may be some additional agricultural problems because of more smog. Higher air temperatures promote smog, producing reactions in the atmosphere.

- *Change in water use.* Higher temperatures would also increase evapotranspiration. This may be offset somewhat by lower plant water use as a result of higher CO_2 concentration. The plants do not have to open their pores as widely to receive the CO_2 needed for photosynthesis. Most observers think the net effect of higher temperatures and increased CO_2 will be higher water consumption, although perhaps not a large change.

- *Potential change in rainfall patterns.* Although more precipitation would be expected worldwide because of greater evaporation, it probably will not be evenly distributed. If the winter storm track is shifted farther north, consequences for California would be serious, because we depend on the southern movement of these storms for much of the winter rain and snow. Rainfall predictions from the global circulation models are probably not reliable. There may be some comfort in the fact that known predictions show little change in annual precipitation. Some models do show drier springs, however, which would compound the loss in spring runoff.

On the other hand, despite drought years, the total water year runoff of the Sacramento River has risen during recent decades.

Reclamation Water Contracting Programs

Since 1979, Reclamation had imposed a moratorium on new long-term contracts for uncommitted water from the CVP because of concerns about environmental and water quality effects in the Delta.

The Coordinated Operating Agreement (COA) enacted in 1986 requires the CVP, in conjunction with the SWP, to operate in conformity with State water quality standards with few exceptions. This action has lifted the moratorium, and Reclamation is now able to resume long-term contracting of available and uncommitted water from the CVP. The law, however, requires an EIS, because entering into new long-term contracts is a major federal action that may have significant effects on the environment in such areas as fisheries and wildlife, energy, land use, population, housing, and related social effects.

Because three distinct areas—the Sacramento River Service area, the American River Service area, and the Delta Export Service area—would be served under the new water contracts, Reclamation has prepared an environmental impact statement (EIS) for each area.

In late 1988, Reclamation distributed three draft EIS's for public review. These drafts disclose probable impacts of selling available and uncommitted water from the Sacramento and Trinity river diversions of CVP.

Because of the overwhelmingly negative comments on the draft EIS's received by Reclamation, it has begun revision of the documents where appropriate. Completion dates for the revised drafts are uncertain at this time. The potential cumulative effects of the water contracts will be very nearly the same as the COA effects in the following section.

Water Supply Reductions in Southern California

Rapidly growing Southern California, with its existing water development facilities and successful legal challenges to sustain or expand its supply, faces increasing dry-year water deficiencies.

Southern California gained an estimated 350,000 new residents during 1988–89, and the area contains five of the nation's 10 fastest-growing counties. In addition to the problem of population growth, the area will soon have to adjust to reduced water supplies from both the Colorado River and the eastern Sierra.

Colorado River Supply. Priorities for use of Colorado River water in California are based on the 1931 *Seven-Part Agreement* as modified in 1964 by the U.S. Supreme Court's decree in *Arizona* vs. *California.* With the Central Arizona Project on line, California can no longer depend on receiving more than 4.4 TAF of Colorado River water per year. As the junior appropriator, MWD is limited to 550 TAF per year of fourth-priority water plus half of any surplus flows on the lower Colorado River. After deducting allotments for three Indian reservations, miscellaneous present perfected right holders, delivery system losses, and possible further rights for water to Indian tribes, MWD could be reduced to about 360 TAF per year—down from a recent use averaging 1.135 MAF per year.

Reduction of water supplies will potentially increase Delta export and inflow, decrease outflow, reduce water quality protection, and increase fish screen losses.

Eastern Sierra Supplies. For several years, environmentalists have been attempting to overturn permits and licenses issued to the Los Angeles Department of Water and Power (LADWP) to divert water from Mono Lake. Finally, in August 1989, a Superior Court ruling mandated drastic cuts in the City's diversions and later, a change in the way that LADWP was preparing to return the increased flow Mono Lake.

LADWP had been diverting up to 100 TAF per year from the Mono Lake Basin, about 17 percent of its annual needs. The recent ruling will reduce the diversion substantially, although a final determination has not been made. LADWP will probably have to rely more on its existing contracts with MWD.

The reduced water supplies from both the Mono Lake Basin and the Colorado River will mean that eventually MWD will have to obtain additional water supplies elsewhere. There are, however, several problems:

- MWD's largest source, SWP, has not been completed, and environmental concerns in the Delta may impede additional deliveries.
- MWD relies on ground water for about one-third of its supply. Expansion of this supply is limited, and current supplies are threatened by contamination and more stringent health standards.
- A third source, large-scale water projects, is either affected by environmental concerns or negative public sentiment.

Environmentalists have suggested that current supplies be used more efficiently, for example, water conservation, waste water reclamation, and re-allocation of water supplies from agriculture to urban use.

In this regard, MWD has agreed with the Imperial Irrigation District to fund conservation measures in exchange for an estimated 100 TAF of water that would be saved.. MWD is working on a similar project with Reclamation to line the All-American Canal in exchange for the water saved. The District has offered to buy Colorado River water from Palo Verde Irrigation District in dry years and is exploring a contract with Arvin-Edison Water Storage District to store water underground during wet years for extraction in dry years.

Beyond year 2010, development of new water projects may be the only way to obtain reliable and adequate water supplies. The State-sponsored projects remaining on the books—which are mainly designed to capture excess winter flows for storage south of the Delta (Delta improvements, KWB, LBG)—are estimated to increase the total SWP supply to between 3.5 and 3.7 MAF. The NDP can facilitate delivery of additional supplies but, by itself, will add only small incremental amounts to the other related projects.

Finally, two recently signed bills will set aside $390.8 million to help resolve a number of the State's water-related issues. Together, the bills form the Environmental Water Act of 1989. Principally designed to protect the sensitive ecology of Mono Lake, the Act provides as much as $60 million to replace water and power supplies lost by LAWPD in preserving the lake.

Local Upstream Increased Use

As growth continues in the northern California region, local water development and use will increase. This could reduce streamflow available for export unless additional storage facilities are added. Increased upstream use can potentially reduce Delta inflow and exports, and reduce instream fish and wildlife benefits.

Upper Sacramento River Fisheries and Riparian Habitat Management Plan

State. Severe declines in salmon and steelhead populations and riparian habitat over the past four decades prompted the California Legislature to enact 1986 legislation calling for preparation of a fisheries and riparian habitat management plan for the Sacramento River, from Keswick Dam to the mouth of the Feather River. The act, SB 1086, created an advisory council composed of 25 members from federal, State, and local agencies and environmental, fishery, and landowner groups.

About 150 years ago, the Sacramento River was bordered by up to 500,000 acres of riparian forest, with bands of vegetation spreading 4 to 5 miles. As agriculture and urban areas developed along the river, the riparian vegetation was gradually reduced. Today, less than 5 percent of the original acreage remains.

Riparian lands provide a highly suitable and often critical habitat for a wide array of birds, mammals, and other wildlife. State and/or federal threatened or endangered species include the bald eagle, western yellow-billed cuckoo, Swainson's hawk, and the valley elderberry beetle, which is endemic to the Central Valley. Species of special concern include the bank swallow and the California hibiscus.

The area also provides habitat for raptors, migratory birds, wood ducks, and other waterfowl.

Goals and policies identified by the advisory council are:

- The habitat protection plan would reestablish a continuous riparian ecosystem along the river between Chico and Redding and reestablish riparian vegetation along the river from Verona to Chico, consistent with the Sacramento River Flood Control Project.

- The Advisory Council's intent is to give the highest priority to a fishery restoration plan that will protect, restore, and enhance wild strains of salmon and steelhead.

- Actions that will maximize habitat restoration for naturally spawning salmon and steelhead will be given second priority. Natural production is intended to be limited only by the carrying capacity of the natural ecosystem.

- Artificial production will be limited to actions that will fully compensate for fish populations that existed at the time their historic habitat was permanently lost due to blockage by construction of dams or other human actions.

- This plan should provide measures necessary to minimize fish losses due to entrainment, predation, and other hazards associated with diversion of water from the upper Sacramento River and its tributaries. Such measures may include installing fish screens, reducing diversions during critical periods, or relocating diversion points to avoid conflicts with fish populations. The owner of the diversion is not responsible for costs. When existing State laws require the owner of a diversion to help pay for these measures, the owner will be expected to participate.

- State and federal legislation should be enacted as soon as possible to provide authority and funding needed to implement the actions contained in this management plan.

- The State of California should commit the necessary funding from a combination of Proposition 70, Proposition 99, and other sources to meet the State's share of the costs.

- The fishery and riparian habitat measures contained herein should be implemented in general conformance with the priorities indicated.

- State and federal legislation should be enacted to authorize an Upper Sacramento River Advisory Council to facilitate implementation of the management plan.

The various potential projects on the upper Sacramento River can decrease Delta outflow, increase Delta exports, reduce water quality protection, and significantly improve Delta fisheries.

Federal. A $185 million measure to restore fish populations in the Sacramento River over the next 10 years has been introduced in Congress. Part of the money would be used to build new fish ladders and more effective fish screens at the Red Bluff Diversion Dam and the Anderson–Cottonwood Irrigation District Dam. Part of the funds would be used to increase the quantity and quality of gravel used for fish spawning and rearing between Keswick and Red Bluff Diversion dams.

Some of the funds would be used to update and expand the Coleman National Fish Hatchery near Redding, to construct new hatcheries, and to build a $50 million device at Shasta Dam to help control downstream water temperatures, which have devastated the salmon run in recent years.

The funds would also be used to reduce the level of toxic zinc and copper leaking from the Iron Mountain Mine complex into the Sacramento River and to improve fish screening at the Glenn–Colusa Irrigation District diversions headworks.

Mitigation Banking

The mitigation banking concept is still in its infancy and is not fully defined. As now applied, the concept involves "wetlands" and "wetlands banking"; in the future, however, this concept could be applied to other ecosystems, such as oak woodlands, native grasslands, forests, etc.

In January 1987, DFG adopted the Wetlands Resources Policy, which states that " . . . it shall seek to provide for the protection, preservation, restoration, enhancement, and expansion of wetlands habitats." Mitigation measures for unavoidable impacts to wetlands must therefore result in no net loss of either wetland acreage or wetland habitat values.

DFG recognizes that in some projects it is not always possible to avoid impacting wetland habitat and that on-site mitigation is at times infeasible or undesirable from a biological perspective. DFG has provided definitions pertinent to wetland mitigation banks in a December 1989

Draft publication, *Guidelines for Establishment and Use of Wetlands Mitigation Banks.* The definitions are as follows:

- "**Qualified Wetland Mitigation Bank.** A single contiguous parcel of land consisting of non-wetland habitat, which has undergone those physical changes necessary to create and optimize the acreage and quality of wetland habitat on the site for the express purpose of providing mitigation credits to offset the adverse impacts to wetlands from approved projects elsewhere.

- "**Bank Developer.** A legal entity empowered to acquire land, to create or restore and maintain wetland habitat upon that land and to operate said land as a qualified wetland mitigation bank pursuant to an operations agreement with DFG. The Bank Developer may employ an agent(s) to actually operate the mitigation bank, provided that said agent(s) has been approved by DFG.

- "**Project Proponents.** Public or private entities acting on their proprietary or management capacity, which seek to implement a project that would unavoidably and adversely impact wetlands and which seek to compensate for the loss of the wetland acreage and/or wetland habitat values through participation in a mitigation bank.

- "**Mitigation Credit.** A unit of measured area supporting wetland habitat and wetland habitat values not preexisting at the bank site prior to bank development. Each such unit shall have been assigned a habitat value by the DFG in consultation with other appropriate resource agencies."

The impacts of projects on wetlands may be offset by a wetland mitigation bank if DFG determines that the following conditions have been met:

- the project is the least environmentally damaging;
- on-site mitigation is either infeasible or undesirable;
- no suitable mitigation site exists closer to the point of impact;
- the project is located no more than 40 aerial miles from the bank site and DFG has concluded that a lesser distance is not needed to assure effective compensation for affected species;
- the project sponsor obtains all necessary permits and written statements from all permitting agencies that use of the selected site is acceptable; and
- DFG consults with all resource conservation agencies and permitting authorities.

Consideration of the potential wildlife mitigation opportunities available for present and future water development projects under the WDWMP may result in the application of the mitigation banking concept and plan discussed on pages 169 and 170.

The mitigation banking concept has the potential, when considered cumulative with other project(s) to reduce the total environmental impacts.

San Joaquin Valley Agricultural Drainage Program

Current agricultural drainage conditions on the west side of the San Joaquin Valley present three basic problems: 1) salt balance, 2) water balance, and 3) toxic or potentially toxic trace elements in subsurface agricultural drainage, which, when discharged to streams, ponds, or wetlands can adversely affect fish and wildlife.

The severity of the toxic problem became known about 1983, with the discovery of deaths and deformities of water birds, which were linked to high selenium levels in agricultural drainage water at Kesterson Reservoir.

In mid-1984, Reclamation, USFWS, USGS, and DFG formed the San Joaquin Valley Drainage Program (SJVDP) to investigate drainage problems and identify possible solutions. The four goals of the SJVDP are to:

- minimize potential health risks associated with subsurface agricultural drainage water;
- protect existing and future reasonable and beneficial uses of surface and ground water from impacts associated with drainage water;
- protect, restore, and, to the extent practicable, improve valley fish and wildlife resources; and
- sustain the productivity of farm land on the west side of the San Joaquin Valley.

In 1987, the SJVDP narrowed its focus on planning alternatives for solving drainage problems to measures that could be taken within the valley itself. In 1989, the SJVDP published a report on preliminary planning alternatives, which would consist of combinations of drainage management strategies falling into seven categories:

- source control to reduce drainage from individual farms;

- management of shallow water tables by pumping;
- treatment of drainage water;
- reuse of drainage water;
- disposal of drainage water in the valley;
- fish and wildlife measures; and
- institutional changes.

Drainage–water reduction and disposal methods include irrigation improvements, reuse of drainage water for propagation of eucalyptus trees and saltbrush, and limited drainage–water storage in ground water and disposal in evaporation ponds. Discharge to the San Joaquin River is included for selenium–free areas or where drainage containing selenium can be safely assimilated by the river. The alternative also involves actions to protect public health and to protect and restore fish and wildlife, including provision of fresh water supplies conserved from irrigation improvements for use on existing wetlands and wildlife areas.

DWR is collecting data and preparing studies on reuse and disposal of agricultural drainage water in the State service area. Analyses emphasize trace elements, such as selenium and arsenic, because of their potential adverse effects on water supplies and the environment. Other water quality parameters, such as nutrients, do not appear to be a problem and are analyzed less frequently.

To determine selenium concentrations in the State service area, DWR has increased its selenium data collection and is working with USGS to investigate shallow ground water in the Tulare Lake Basin. Together with information on applied irrigation rates, cropping patterns, soil types, and precipitation, these data are being evaluated to identify possible trends in selenium leaching.

San Joaquin River Basin Planned Development

Development in the form of water transfers, new projects, enlarged projects, re–operated projects, and new studies continue in the San Joaquin River Basin.

Mokelumne River Basin Study. See *New Melones Conjunctive Use Program.*

Friant Dam and Lake Millerton. Friant Dam was constructed by Reclamation in 1948. The enabling legislation said nothing about protecting fish and wildlife resources. In many years, only enough water is released into the San Joaquin River to supply downstream canals and some of the riparian pumps.

Recently, local interests have indicated that the Reclamation should re–operate the project and install some facilities to restore and enhance downstream flow and habitat. Reclamation is committed to work with State and local interests on a San Joaquin River Basin fishery recovery program.

San Joaquin River Comprehensive Program. A program has been started to develop environmentally compatible solutions to water supply and flood control problems of the San Joaquin River. Actions that will enhance fisheries, wildlife habitat, and recreation without adversely affecting water supply and flood control will be identified. In September 1989, several agencies and other interested parties met to discuss program objectives and the formation of work groups.

Suisun Marsh Planning And Implementation

Suisun Marsh in southern Solano County comprises about 116,000 acres. It supports as many as 200 species of wildlife. The brackish water in Suisun Marsh fosters plants and provides habitat for wildfowl.

The marsh's salinity affects the wildlife food chain, and the Sacramento–San Joaquin Delta outflow affects the marsh salinity. Decision 1485 required DWR and Reclamation to develop a plan to meet specified water quality standards within the marsh. Initial facilities were completed in 1983, and a coordinated protection plan for Suisun Marsh water quality was developed. The protection plan, published with an EIR in 1984, includes:

- a program to construct (as required) a major tidal pumping station, three conveyance channels, and one additional distribution system; and
- a system to monitor compliance with water quality standards and measure the performance of the facilities constructed. The monitoring plan has been implemented.

In March 1987, DWR, Reclamation, DFG, and the Suisun Resource Conservation District signed the Suisun Marsh Preservation Agreement. The agreement includes definitions of marsh water quality standards and construction staging, as well as details for implementing the Plan of Protection.

DWR has been evaluating the effectiveness of the Suisun Marsh salinity control gates facility in maintaining lower salinity levels in the marsh's interior channels since the gates began operating in October 1988. There was an immediate and dramatic reduction in salinity levels in the eastern and middle reaches of Montezuma Slough, and although less dramatic, lower salinities were observed in the western reach just above Grizzly Bay. This western reach did appear to be vulnerable to encroaching salts over extended periods of low outflows and strong tidal currents. Further evaluation will be necessary before DWR can determine the full impact of the operation on the entire western portion of Suisun Marsh.

DWR is conducting this evaluation in cooperation with the other parties of the Suisun Marsh Preservation Agreement (DFG, Reclamation, and the Suisun Resources Conservation District). SWRCB has agreed that DWR and Reclamation can operate under the agreement's Interior Marsh Deficiency Standard through the test operation of the control gates and development of criteria for the most effective operation.

According to the agreement, DWR is to operate the gates for three years and monitor their impact on marsh salinities. The data, along with information gained from running an upgraded Suisun Marsh stage and salinity model, will be used to determine the need and potential effectiveness of additional marsh facilities. If DWR finds that additional facilities are needed to maintain marsh salinity, the next stage is to be in place by October 1, 1993.

General Obligation Grant and Loan Programs

Since 1976, DWR has been involved with two loan and grant programs to assist counties in upgrading their water systems: the Safe Drinking Water Bond Law and the Water Conservation Bond Law.

The Safe Drinking Water Bond Law has provided loans and grants to bring domestic water systems up to drinking water standards. Substituting pipelines for open ditches is one method of improving water quality, and has the additional effect of reducing conveyance losses. After Proposition 55 (Safe Drinking Water Bond Law of 1986) passed, 1,976 applications for funds were received; 237 applicants were invited to submit final applications. The bond funds are over-subscribed, however, and new applications are not now being accepted.

Proposition 81 (November 1988 ballot) provided an additional $75 million to continue the Safe Drinking Water loan and grant program. The Department of Health Services, after public notice and hearing and with the advice of DWR, will establish a priority list of projects to be considered for financing under this law. At that time, new applications will be invited.

The Water Conservation Bond Law (1984) provides funds to DWR to be loaned to irrigation districts, water agencies, and municipalities at low interest rates for use in cost-effective, capital outlay water conservation programs. The maximum loan has been $5 million for a single project, such as lining a distribution canal and replacing distribution mains. The Safe Drinking Water Bond Law of 1986 added ground water recharge projects and feasibility studies as qualifiers for loans. Funds provided under the 1984 law are committed, and DWR has adopted a priority list of applicants for funds provided under the 1986 law.

The first water conservation project completed under the 1984 law was the Sand Trap Siphon Project, dedicated in June 1988. Georgetown Divide Public Utility District received $469,000 for this project. An inverted siphon was constructed to replace a section of unlined ditch. This project is expected to save 1,045 AF of water each year.

A new Water Conservation Bond Law of 1988 (Proposition 82) received voter approval in November 1988. The program provides for a bond issue of $60 million for local water project assistance, water conservation programs, and ground water recharge facilities. Of the $60 million total, $40 million will be a continuation of or similar to Proposition 44 of 1986, and $20 million will be made available for loans to local agencies for purposes that include development of new basic water supplies.

Table 6-2 summarizes current general obligation bond programs of DWR and Department of Health Services.

Cumulative Impacts on Bay-Delta Estuary Based on DWR Bulletin 160-87

Analysis of projected water demand and supply balance in the service areas can be a measure of future cumulative impacts of NDP when combined with other projects. Table 6-3 shows applied and net water use in different regions of the State as reported in DWR Bulletin 160-87, *California Water: Looking to the Future,* November 1987.

Net water use is lower than applied water because it takes into consideration the substantial reuse that commonly

Table 6–2
Overview of DWR and Department of Health Services
General Obligation Bond Programs

Program Name	Principal $ Amount[1]	Description	Terms
Safe Drinking Water Bond Law of 1976 (Proposition 3) June 8, 1976. AB 121/Ch.1008/ 1975 (Proposition 9) November 4, 1980. AB 2404/Ch.252/1980	145,000,000L 30,000,000G 175,000,000T	Loans up to $1,500,000 to bring domestic water systems up to drinking water standards. Grants up to $400,000 to public agencies unable to repay a loan.	Loans up to 50 years at State's general obligation bond interest rate.
Safe Drinking Water Bond Law of 1984 (Proposition 28) November 6, 1984. AB 2183/Ch.378/1984.	50,000,000L 25,000,000G 75,000,000T	Loans up to $5,000,000; Grants up to $400,000; Same purposes as Proposition 3.	Same as Proposition 3, except interest rate reduced as per Proposition 55.
Safe Drinking Water Bond Law of 1986 (Proposition 55) November 4, 1986. AB 2668/Ch.410/1986	75,000,000L 25,000,000G 100,000,000T	Same as Proposition 28. Investigation loans and grants up to $25,000 each also available	Same as Proposition 3, except interest rate at half State's rate. Reduced rate retroactively applied to Proposition 28.
Safe Drinking Water Bond Law of 1988 (Proposition 81) November 8, 1988	50,000,000L 25,000,000G 75,000,000T	Same as Proposition 55.	Same as Proposition 55.
Water Conservation Account Clean Water Bond Law of 1984 (Proposition 25) November 6, 1984. AB 1732/Ch.377/1984.	10,000,000 + 500,000 for administration	Loans up to $5,000,000 for cost-effective capital outlay water conservation projects to public agencies	Up to 25 years, at half State's general obligation bond interest rate.
Water Conservation and Water Quality Bond Law of 1986 (Proposition 44) June 3, 1986. AB 1982/Ch.6/1986.	75,000,000	Loans up to $5,000,000 for (A) cost-effective capital outlay water conservation projects, and (B) ground water recharge projects. Feasibility study loans up to $100,000 each also available.	Up to 20 years at half State's general obligation bond interest rate.
Water Conservation Bond Law of 1988 (Proposition 82) November 8, 1988	60,000,000	$40,000,000, same as Proposition 44. $20,000,000 is for loans to develop new basic water supplies.	Same as Proposition 44.

[1] L = Loan; G = grant; T = total.

water use, which generally reflects population growth, is expected to increase. The increase in projected net water use is substantial in all regions.

Table 6–4 shows statewide water demands for recent and near–future levels as reported in Bulletin 160–87. Except for the Central Valley Project, developed but uncommitted supplies are relatively small. Some of the 1.4 MAF deficit can be met from the uncontracted CVP project supplies. The remainder can be satisfied from a variety of other sources.

For the SWP, the present dependable supply is about 2.4 MAF. Projected near–future water requirements for the SWP service area are about 3.6 MAF, assuming 1) 250 TAF of water conserved in the Colorado River Basin becomes available, 2) an increase in waste water reuse of 200 TAF in the SWP service area, and 3) continuing water conservation measures. Under those assumptions, existing SWP facilities would have a deficit of dependable supplies in the near future. First and later phase facilities adding up to about 900 TAF in new supplies are:

- South Delta facilities,
- North Delta facilities,
- Los Banos Grandes Reservoir,
- Kern Water Bank, and
- Purchase of interim CVP supplies.

Figure 6–2 shows the percentage of years in which dependable supplies will be available with existing and planned facilities. With the additional facilities, dependable water supplies will increase about 900 TAF per year and will meet near–future water requirements 90 percent of the time.

A need for dependable supplies amounting to as much as 0.4 MAF in a given year would remain after the major facilities and actions listed above are implemented. This would not be a chronic shortage, but a shortage that could occur in dry years. A temporary shortage of this magnitude may well be manageable with extraordinary conservation efforts (measures taken only during times of drought) and such actions as water marketing, water banking, or extra withdrawals from ground water storage.

Not all the water resources activities listed in Table 6–5 will be implemented in the near future, and some will extend into the future—beyond the scope of current statewide water resources planning. Just how all these activi-

Water Supply and Water Needs Update

Several events have occurred since Bulletin 160–87 was published which place an additional burden on agencies attempting to keep pace with the increasing needs for water in California. These events will also accelerate the need to implement the Delta Water Management plans, water banking programs and conservation activities recommended in Bulletin 160–87. The most significant of these events are described below.

Population Increases. In 1985, the Department of Finance (DOF) projected 36.3 million people in California by 2010. Interim projections in early 1990 by DOF increased the 2010 projections to 39.4 million. This number will be further revised when the results of the 1990 census are available. With the present population at 30 million, this latest projection means California will be adding an average of nearly 500,000 people per year for the next 20 years. Increases during the past three years have considerably exceeded that rate.

Using the same assumptions as in Bulletin 160–87, i.e., implementation of extensive urban water conservation measures, and transfer of agricultural water supply to urban uses where encroachment onto agricultural lands is projected, a one million increase in population in the State Water Project service area increases net water use by at least 120,000 acre–feet per year. With the 2010 population in the SWP service area projected to be 2.3 million people more than in Bulletin 160–87, we expect water needs to be 276,000 acre–feet greater than previously projected.

Supply Reductions. In Bulletin 160–87, no reduction in supply for Los Angeles from the Mono Lake–Owens Valley system was assumed due to uncertainty of the situation at that time. As a result of recent court decisions and agreements, it appears the average annual supply available to the South Coast region will be reduced by about 100,000 acre–feet per year.

Ground Water Contamination. No reduction in the 1985 level of ground water usage in the South Coast region due to contamination was assumed in Bulletin 160–87. Since then, several wells have been taken out of production in the San Fernando Valley, and widespread contamination from sewage and cow manure from dairy herds in the Santa Ana River watershed threaten the water supply for 1.5 million people. Even though programs for clean–up of the contaminated water are planned or underway, a reduction in the usable annual supply averaging at least 50,000 acre–feet by 2010 appears to be a reasonable assumption.

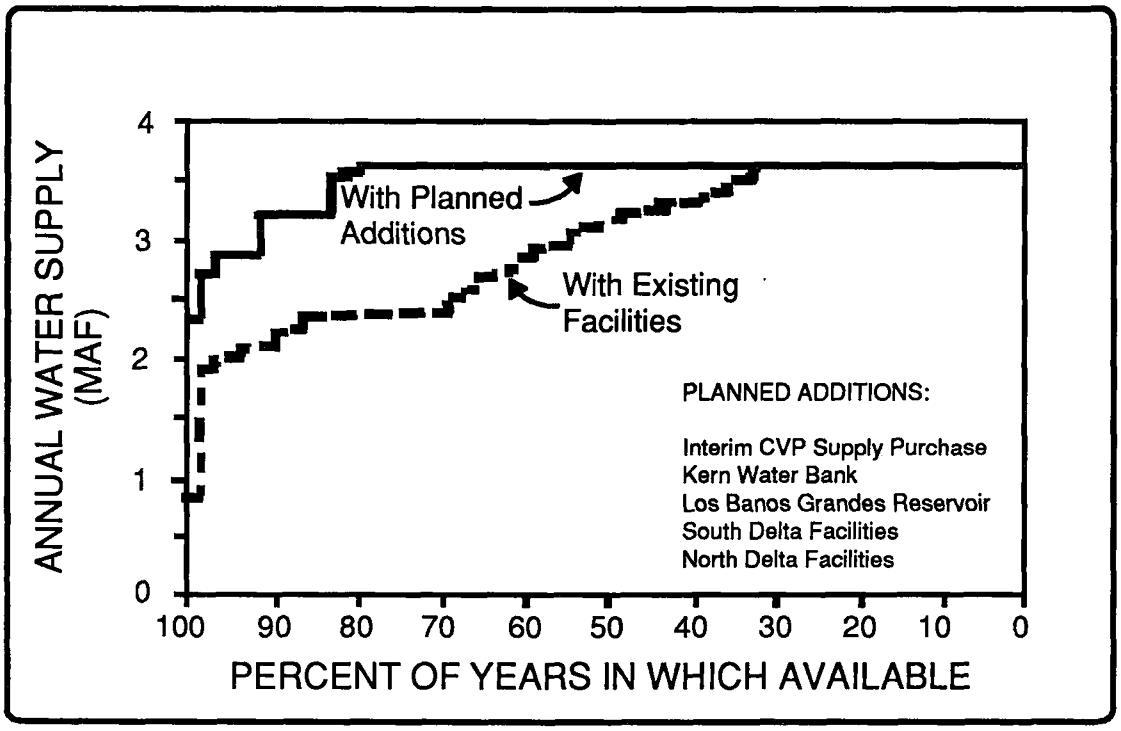


Figure 6–2. SWP Water Capability With Existing Facilities and Planned Additions

tend into the future—beyond the scope of current statewide water resources planning. Just how all these activities interrelate is difficult to project. However, certain assumptions can be made to combine actions with mitigation and thus produce favorable effects on the cumulative impacts of NDP. Other assumptions could combine actions without mitigation, thereby producing adverse impacts.

In addition to SWP and CVP water planning actions, many factors have affected, and will continue to affect, the estuary cumulatively. Among these are:

- and reclamation and bay fill;
- sediment load from early gold mining activity;
- toxic chemical, pesticide, and waste water pollution from cities, farms, and boats;
- concentrated salt loadings from irrigation and soil leaching agricultural activities;
- commercial, sport, and illegal fishing;
- construction and maintenance of ship channels;
- use of natural inflows by upstream and Delta agricultural and urban development;
- Delta diversions by the CVP, SWP, local Delta municipal and industrial water users, and Delta agricultural water users;
- levee failures in the Delta;
- wavewash erosion caused by boat traffic;
- direct diversions and thermal pollution of power plant operations;
- increased urbanization around San Francisco Bay-Delta area, leading to loss of valuable wildlife habitat.
- agricultural practices and crop patterns that decrease the value of the Delta to wildlife;
- levee maintenance programs in which riprap replaces riparian habitat; and
- upstream storage and regulation of natural inflows by the Hetch Hetchy Aqueduct, Mokelumne Aqueduct project, CVP, SWP, and others.

Table 6–3
Regional Use of California's Developed Water Supplies, 1985 and 2010
in 1,000s of acre–feet

Regions	Applied Water			Net Water Use		
	Recent Deliveries	Near Future	Change	Recent Deliveries	Near Future	Change
San Francisco Bay and Central Coast	2,780	2,980	200	2,450	2,640	190
South Coast	4,040	4,700	660	3,760	4,360	600
Sacramento River	8,700	10,110	1,410	7,480	7,830	350
San Joaquin River and Tulare Lake	18,690	19,270	580	14,550	15,010	460
Colorado River	3,930	3,710	–220	4,030	3,690	–340
Remaining Regions	2,320	2,460	140	1,950	2,090	140
State Totals	**40,460**	**43,230**	**2,770**	**34,220**	**35,620**	**1,400**

Table 6–4
Projected Water Demands (in millions of acre–feet)

Source of Supply	Recent Net Use	Near Future Net Use	Change
Local surface water	9.2	9.2	—
Ground water safe yield	6.0	6.1	0.1
Federal Central Valley Project	7.0	7.8	0.8
Other federal sources	1.3	1.3	—
State Water Project	2.4	3.2	0.8
Colorado River	5.0	4.2	–0.8
Local agency imports (excluding the Colorado River)	1.0	1.1	0.1
Reclaimed waste water	0.3	0.5	0.2
Ground water overdraft	2.0	1.8	–0.2
Other sources	—	0.4	0.4
Totals	**34.2**	**35.6**	**1.4**

Table 6-5
Potential Future Cumulative Effects of North Delta Water Management Facilities and Potential Related Projects or Actions on the Bay-Delta Estuary

Project or Action	Potential Cumulative Effect
State Water Project Additions to Year 2010 • Delta Pumps • Interim CVP Purchase • Kern Water Bank • Los Banos Reservoir • South Delta Program • North Delta Program	Increase present dependable supply from 2.3 MAF to 3.6 MAF 90 percent of the time. Temporary 0.4 MAF shortage expected 10 percent of the time to be managed by extraordinary conservation and water management measures. Improvements in Delta flow patterns and operational flexibility can reduce fishery impacts and improve drinking water quality. Delta flood protection including protection of valuable wildlife habitat. Net decrease in Delta outflow.
Water Conservation Water Reclamation Water Transfer Water Sharing Conjunctive Use Desalination	Increase emphasis on these measures to meet future water needs. By 2010 conservation will reduce annual demands and Delta exports by 1.3 MAF. Waste water reuse will increase annually to further reduce diversions by 200,000 AF. Calaveras-Stanislaus Conjunctive Use Program could provide improved Delta inflow and water quality. Increasing population, loss of Mono Lake and Colorado River supplies and ground water contamination will further accelerate acceptance of these measures.
West Delta Water Management Program	Improvement in up to 10,000 acres of wetlands and diverse habitat for wildlife, including rare, threatened and endangered species. Protection against salinity intrusion resulting from flooding.
Suisun Marsh Agreement	Protection of 110,000 acres of estuary wetlands providing habitat for 200 species of birds and 60 species of mammals, amphibians and reptiles.
Harvey O. Banks Delta Pumping Plant Fish Agreement	Significant corrective actions for striped bass, salmon and steelhead. Specifically defines DWR mitigation commitment for increased pumping limits. Present actions include striped bass growing facility and upstream spawning restoration.
Delta Flood Protection Act	Increases protection of Delta waters from salinity intrusion due to flooding and protects valuable habitat including habitat for rare, threatened and endangered species.
Delta Wetlands Project	Project planning being conducted by private corporation. Provides added water supply and waterfowl habitat.
Storage North of the Delta	Planning is being conducted for Auburn Dam and Red Bank Project. Storage would reduce winter and spring Delta inflow and increase summer and fall inflow. Additional flood control and dry-year salinity protections would be provided.
Upper Sacramento and San Joaquin River Restoration Program	Improved fishery, wildlife, and riparian habitat to cumulatively add to estuary populations. Actions could include spawning restoration, water temperature improvements, hatchery improvements, and installation of fish screens.
Local Upstream Increased Use	Protected by area of origin law; however, will cause cumulative reduction of inflow and Delta outflow.
Drinking Water Quality. Wetland and Waste Discharge Action	Further continued reductions of Bay pollutants and restrictions of reduced wetlands loss due to development. Continued studies and actions to protect drinking water standards.

Cumulative Impacts of SWP Deliveries

The State of California has signed contracts with 30 water agencies throughout the State that require the SWP to deliver a maximum of 4.23 MAF after 2020. Table 6–6 shows projected water deliveries for the SWP at the 2035 level.

Table 6–6
Projected SWP Water Entitlement Requests, Year 2035

Area	1,000 AF
Feather River	40
North Bay	67
South Bay	188
San Joaquin Valley	1,355
Southern California	2,497
Central Coastal*	70
TOTAL	4,217

*The Central Coastal service area's entitlement has been reduced from 82,700 AF to 70,000 AF. However, it may be restored to full entitlement in the future.

As mentioned in the previous section, the additional yield of the SWP system at the ultimate level of development is an estimated 900,000 AF..

If it is assumed that the additional yield is distributed in proportion to the service areas' total SWP entitlement, the distribution would be as follows:

Area	Acre–feet
North Bay	14,400
South Bay	40,500
Central Coastal	18,000
San Joaquin Valley	290,700
Southern California	536,400
Total	**900,000**

The Feather River service area is excluded because, as an area of origin, it will receive its full entitlement with or without the proposed projects. The Central Coastal entitlement assumes construction of the Coastal Aqueduct. Of the total for the San Joaquin service area of ***290,700*** AF, the urban allotment would be about ***34,900*** AF. And, as mentioned previously, the additional supplies provided by these projects should not be considered as "new" supplies in the Southern California service area because they are less than the amount required to compensate for future reductions in current supplies (***835,000*** AF).

Numerical estimates of population supported by these supplies can be derived:

Area	Population
North Bay	72,000
South Bay	202,500
Central Coastal	90,000
San Joaquin Valley	99,700
Southern California	0
Total	**464,200**

Because deliveries to the Southern California service area are needed to partially offset future losses of water supplies, they would not be considered as supporting "new" population. Because of the limitations of such a numerical approach, these numbers are provided for reference only and could be viewed as the estimate of maximum growth. Water supply and growth–inducing impacts are discussed in detail under "Growth–Inducing Impacts."

To meet the additional deliveries that will ultimately be requested by the SWP contractors, the H.O. Banks pumping diversions out of the Delta will increase. Table 6–7 reflect the projected changes in the average monthly ex ports from the Delta. Additional deliveries and exports, along with reduced carriage water requirements under the preferred alternative will change the overall operation of the SWP system and its upstream release pattern. Table 6–8 shows a comparison of the average monthly Delta outflow between the no–action and the preferred alternative. Changes in the monthly outflow are also shown graphically in Figures 6–3 and 6–4. These figures show the frequency of the monthly Delta outflow as projected in the 57–year simulation studies of the no–action and the preferred alternative.

Local Government Policies and Impact Mitigation

Approval of any growth in the service areas is the responsibility of county or city governments. If local government decision makers in the service areas decide to allow additional urban expansion as a direct result of the project, a number of environmental impacts may occur. However, without control over the use of the delivered water, DWR

Table 6–7
Comparison of Average Monthly Delta Exports Between The No–Action and Preferred Alternatives*
(SWP Demand = 4.23 MAF)

Month	Total Delta Exports No-Action (cfs)	Total Delta Exports Preferred Alt. (cfs)	Difference (cfs)	% Change
January	12801	12961	160	1.3
February	13373	13347	-26	-0.2
March	12505	12574	69	0.6
April	11630	12104	474	4.1
May	5490	5492	2	0
June	4772	4615	-157	-3.3
July	7061	6940	-121	-1.7
August	7454	7232	-222	-3
September	7604	8613	1009	13.3
October	9057	9244	187	2.1
November	12429	13063	634	5.1
December	12199	12701	502	4.1

* Delta exports include H.O. Banks P.P., Tracy P.P., North Bay Aqueduct, and Contra Costa Canal diversions. These values do not include the effects of future mitigation measures that could alter operation.

Table 6–8
Comparison of Average Monthly Delta Outflow Between The No–Action and Preferred Alternatives*
(SWP Demand = 4.23 MAF)

Month	Total Delta Outflow No-Action (cfs)	Total Delta Outflow Preferred Alt. (cfs)	Difference (cfs)	% Change
January	31412	31552	140	0.4
February	38028	38113	85	0.2
March	28468	28581	113	0.4
April	20697	21001	304	1.5
May	17373	17394	21	0.1
June	11947	11946	-1	0
July	7439	7240	-199	-2.7
August	5540	4479	-1061	-19.1
September	4119	2747	-1372	-33.3
October	6189	6077	-112	-1.8
November	8365	7984	-381	-4.6
December	16428	16357	-71	-0.4

* Delta outflow includes D-1485 minimum required outflow, carriage water, and surplus Delta outflow. These values do not include the effects of future mitigation measures that could alter operations.

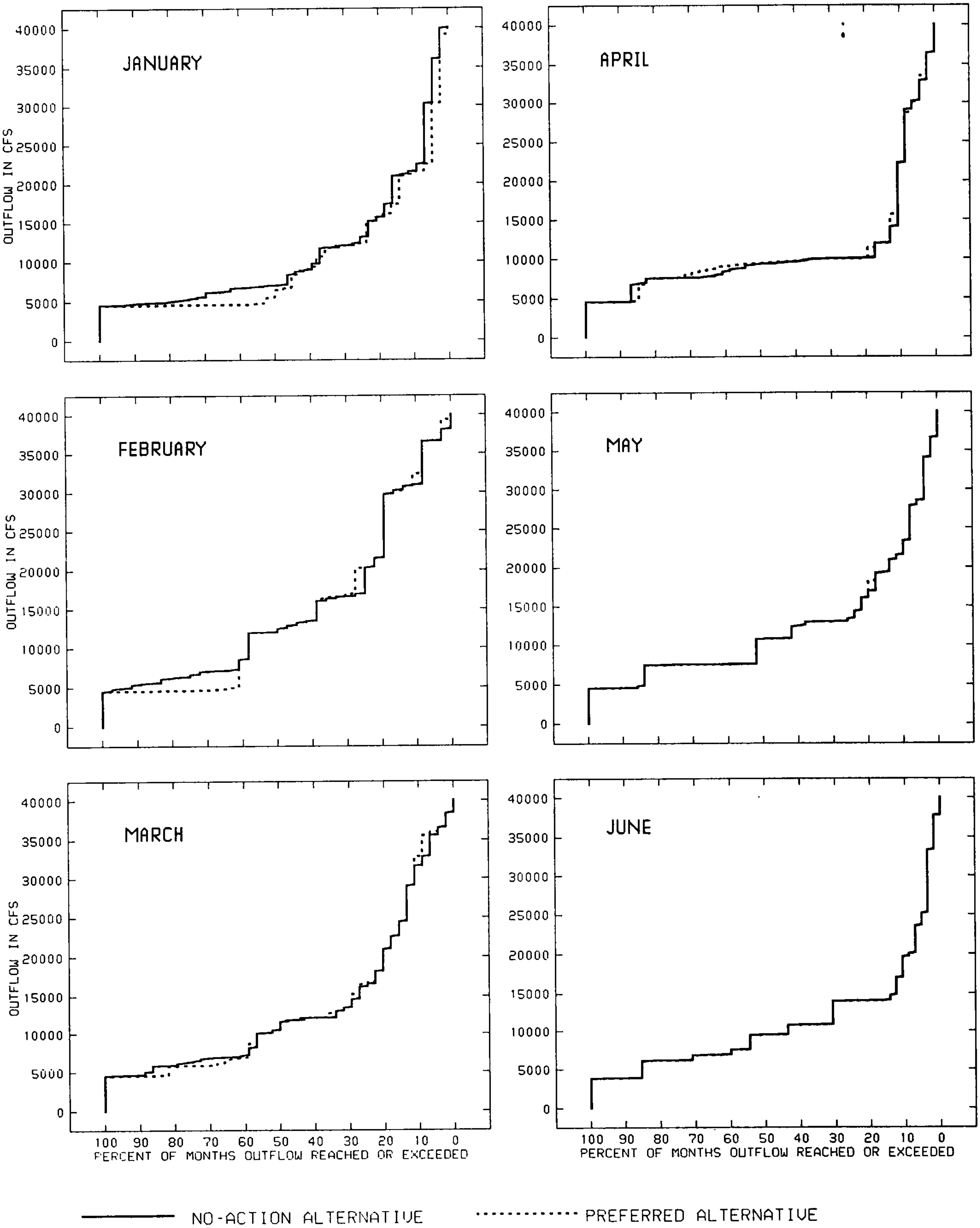


Figure 6-3. Frequency of Total Monthly Delta Outflow — SWP Demands = 4.23 MAF

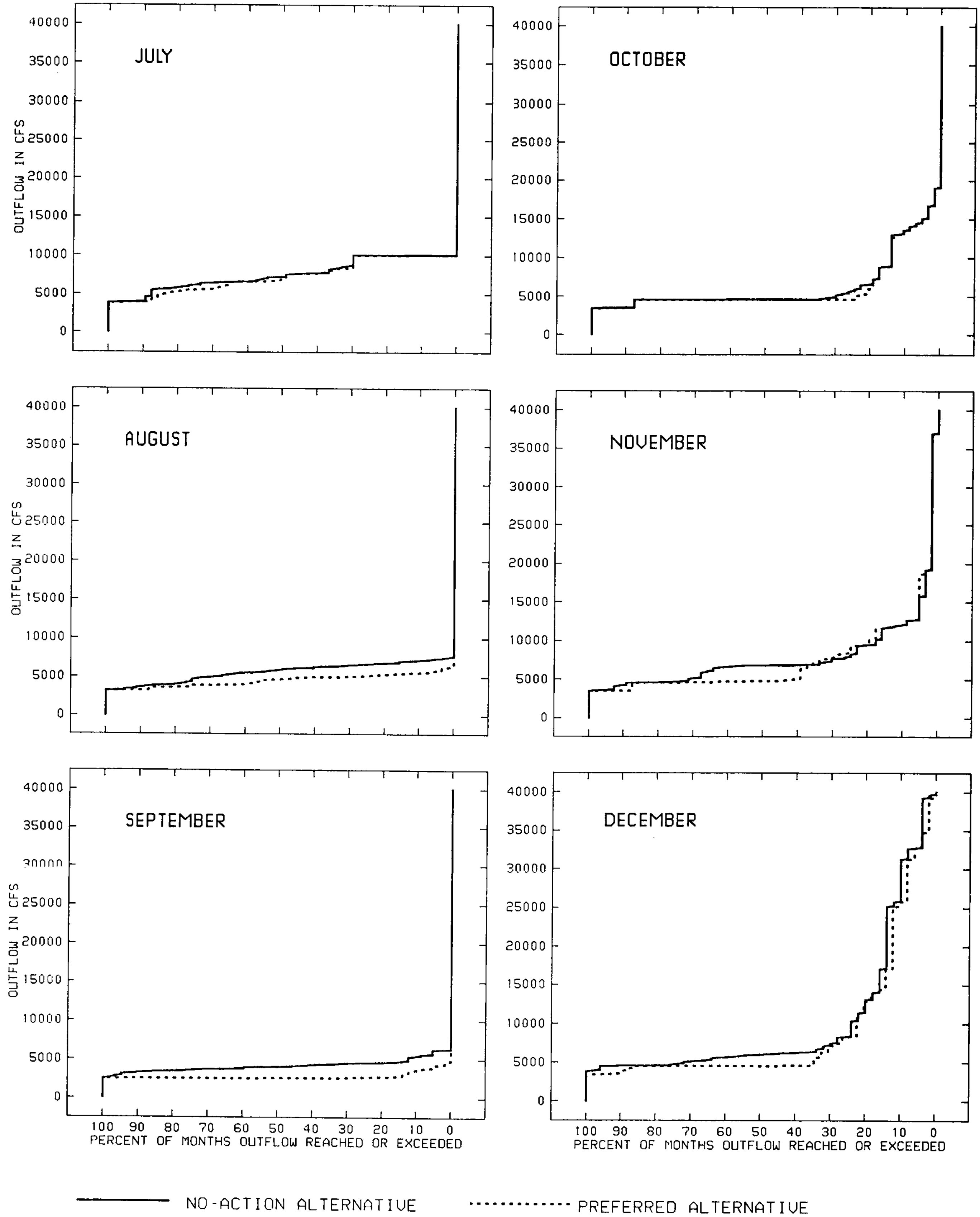


Figure 6-3 (Continued). Frequency of Total Monthly Delta Outflow — SWP Demands = 4.23 MAF

has no means to accurately predict the magnitude of these impacts. These impacts are more properly addressed in local general plans, comprehensive plan EIRs, and specific project EIRs.

Although the decision to allow urban expansion is under local control, DWR would offer the following suggestions to local planning agencies to mitigate the impacts from this expansion:

(1) Identify and inventory quality agricultural lands, sensitive habitats, and wildlife corridors within their jurisdictions. Determine the priority of the inventoried lands, based on habitat quality and development pressures.

(2) Reserve a portion of the additional revenue from development projects and increased tax base for acquiring sensitive habitats and wildlife corridors.

(3) Provide tax incentives for maintaining agricultural lands in production.

(4) The impacts of habitat isolation and fragmentation may be alleviated by the maintenance of large contiguous habitat areas interconnected by a network of unbroken wildlife corridors. These should be coordinated with adjacent counties and incorporated into the general plans.

(5) Identify areas of marginal agricultural and environmental value. Encourage high-density development in such areas through the use of fee incentives. Such distribution of development will allow projected population increases with minimal environmental or agricultural impacts.

Cumulative Impacts of CVP Deliveries

Article 10 (h) of the Coordinated Operation Agreement commits the parties to negotiate a separate contract specifying that excess capacity in the pumping and conveyance facilities of the SWP would be used to increase the amount of water the CVP can deliver from the Delta. This is a separate action, requiring a separate contract or agreement and a separate environmental impact report. With its present Delta export facilities, the CVP lacks the pumping and conveyance capacity to deliver to its existing and potential contractors south of the Delta all the potentially exportable CVP water available in the Delta at certain times.

The SWP has capacity in the California Aqueduct for wheeling CVP supplies at the current level of SWP system development. If proposed storage projects south of the Delta are implemented, wheeling capacity during the winter will be severely restricted. With wheeling through SWP facilities, the effect of the CVP's capacity limitation would be lessened.

Wheeling of the type covered under Article 10 (h) could represent increased exports from the Delta. Such wheeling is distinguishable from other wheeling covered under Article 10 by the fact that the other wheeling, for outages and to make up for the May–June pumping restrictions, is already established and serves only to maintain—not expand—the water supply services of the SWP and CVP.

To the extent that some wheeling arrangements negotiated pursuant to Article 10 (h) could increase project exports from the Delta, the increase could cause environmental impacts incremental to those associated with the existing level of project operations. However, any future wheeling arrangement would have to be carried out within the protective flow and quality provisions of the SWRCB's Delta standards and would require a separate EIR/EIS and contract.

Any incremental impacts of wheeling arrangements negotiated pursuant to Article 10 (h) cannot be quantified or specifically described until the details of these arrangements are known. Early indications from operational studies suggest that the SWP has little remaining pumping capacity and conveyance capacity available for wheeling with existing facilities and restrictions. The potential for wheeling would increase if SWP conveyance facilities were expanded.

Further analysis of the environmental impacts of wheeling may be found in the following future and current documents:

- the water conveyance and purchase contract EIR/EIS now being prepared and tentatively scheduled for release in late 1990;
- the environmental statements being prepared by Reclamation concerning proposed water service contracts;
- any environmental document prepared in connection with new Delta standards that succeed those of Decision 1485; and
- this environmental impact study for the NDP, the results of which indicate that the impact of wheeling would increase only slightly with implementation of the NDP because of other restrictions and limitations.

Other Cumulative Impacts

Other cumulative effects associated with potential water development above the Delta probably would be similar to, and would increase the impacts of, past surface water development. Past projects on the Sacramento, San Joaquin, and Trinity river systems have had a variety of beneficial and adverse effects, including:

- development of water supplies for local and statewide needs;
- development of hydroelectric power;
- increased power requirements;
- improved navigation on the Sacramento River;
- creation of reservoir recreation areas and fisheries;
- increased flood control;
- creation of jobs;
- displacement of people and wildlife;
- inundation of lands, archeological sites, and live streams;
- blockage of anadromous fish runs; and
- changed flow regimes, sediment regimes, water quality, and seepage conditions along affected streams.

Cumulative effects of offstream storage south of the Delta would include:

- new recreation opportunities and reservoir fisheries;
- creation of jobs;
- displacement of people and wildlife;
- inundation of lands and archeological sites;
- improvement in quality of water delivered to service areas;
- a net increase in power requirements; and
- ground water programs south of the Delta, which would involve construction of wells and distribution systems, as well as local water quality and hydrologic impacts and increased power requirements.

Growth Inducement

CEQA requires a discussion of the ways in which a proposed project could " . . . foster economic or population growth, or the construction of additional housing, either directly or indirectly, in the surrounding environment. Included in this are projects which would remove obstacles to population growth."

The location, timing, and magnitude of economic and population growth within a region are determined by a multitude of interrelated economic, social, and political factors, including:

- employment opportunities;
- availability and cost of natural resources, including land, water, and energy;
- the availability and cost of housing;
- the adequacy of community infrastructure (transportation facilities, fire and police protection, schools, recreational facilities, etc.);
- local government policy concerning growth issues (zoning ordinances, general plans, etc.); and
- participation in the National Flood Insurance Program.

Whereas each of these variables influences growth, it is very difficult to ascertain whether a change in one of them is sufficient to cause a significant change in community growth rates. Economic growth is discussed in Chapter 5. Following is a discussion of population growth.

Because minimal amounts of water are necessary to sustain life, water must be available if growth is to occur. However, rarely will the provision of water alone stimulate growth if all the other factors listed above are not conducive to growth. But, if all the other variables are conducive to growth, and no water supplies are available, then the provision of water may be growth inducing since it could "remove a barrier to growth."

Several factors must be examined in order to determine if the proposed project is growth inducing. First, are there alternatives (both demand management and supply augmentation) that could be implemented in the absence of the proposed project? If the proposed project is the only source of water available to a region, it may in fact remove a barrier to growth, and, therefore, be growth inducing. However, if feasible alternatives are available (even if more expensive than the proposed project), it can then be assumed that they would be implemented in the absence of the project.

Hence, with or without the project, growth will occur; the only effect of the project is to use a less expensive source of water. Another factor that needs to be considered is local government policy regarding growth. Most communities in the State have implemented land use policies through their general plans and zoning ordinances that attempt to manage growth in conjunction with their available resources. These plans address population growth, land use, circulation, public services, and environmental resources. Typically, the strength of these plans in managing growth varies from community to community.

Finally, the determination of whether a particular water supply is growth inducing depends upon how it is used. For example, if the project's yield is used in addition to current surface and ground water supplies, then the resulting growth-inducing impacts could be considerably larger than if the yield were used to replace existing supplies (such as overdrafted ground water basins).

Since it has been determined that population growth will occur with or without the project and that the project's yield can be a replacement for some existing water supplies, the project is not expected to be growth inducing. (See also Chapter 5.)

Mitigation Measures for Cumulative Impacts

Various actions such as Decision 1485, the Suisun Marsh facilities, and DFG stocking programs have benefited fish and wildlife in the Delta. Studies by State, federal, and local agencies and private groups have provided much information, from which laws protecting fish and wildlife have been enacted. Today, at least 30 State and federal policies, as well as agency regulations, help protect the Delta's environment. Physical facilities such as fish screens at CVP and SWP pumping plants have been relatively effective in salvaging fish from export water. Funds from State, federal, and local sources for protection of fish and wildlife resources are in the many millions for ecological studies and physical facilities.

Mitigation measures for cumulative impacts due to future State, federal, and local water development generally consist of:

- safeguards by laws, regulations, and water rights standards;
- contracts;
- physical measures and;
- studies and water management programs.

Safeguards

State and federal laws that provide safeguards include:

- Area of Origin Law,
- County of Origin Law,
- Davis-Dolwig Act,
- Delta Protection Act,
- Burns-Porter Act,
- California Environmental Quality Act,
- National Environmental Policy Act,
- National Fish and Wildlife Coordination Act,
- National Clean Water Act, and
- Provisions in Congressional Authorization of Federal Water Projects.

State and federal regulatory agencies administering the laws include the SWRCB, Regional Water Quality Control Boards, EPA, and the Corps.

Contracts

Binding contracts are negotiated between project operators and various interests. DWR has executed contracts with several Delta water agencies that commit DWR to provide reliable water supplies and qualities under the Delta Protection Act. These contracts provide a further safeguard for Delta protection. DWR is continuing negotiations with other Delta interests.

Contracts for management of fish and wildlife resources in San Francisco Bay–Delta estuary can be broadened as to scope and the participating agencies. Such contracts would specify mitigation measures identified by studies and negotiations.

The agreement for coordinated operation of the SWP and the CVP allocates available supplies and shortages between both projects after meeting in-basin obligations, including Delta water quality objectives.

Physical Measures

Potential physical mitigation measures for identified significant impacts are listed below. Specific measures could be incorporated in contracts.

- fish—hatchery construction, adjustment of reservoir releases, habitat modification, establishment of reservoir fishery, fish screens and return systems, export curtailments, and fish stocking programs;

- wildlife—purchase of replacement lands, capture and removal of species, control fencing, escape devices; mitigation in Suisun Marsh as specified in the Environmental Impact Report and Plan of Protection;

- socioeconomic—payment of increased public services caused by project workforce.

- cultural—avoidance or removal of identified cultural resources where possible, purchase of private property where necessary;

- recreation—construction of recreational facilities;

- soils and vegetation—re-establishment of native vegetation, erosion control techniques, replacement of soil and topography where possible;

- transportation — relocation of roads and railroads; and

- utilities — relocation of utilities.

Studies and Water Management Programs

State legislation passed in 1986 created an advisory council composed of 25 members from federal, State, and local agencies, and environmental, fishery, and landowner groups. The Council's "Upper Sacramento Fisheries and Riparian Management Plan" proposed 20 action items for restoration of fisheries and riparian habitat along the upper Sacramento River and its tributaries.

Federal legislation appears to be progressing through Congress to provide money to restore fish populations in the upper Sacramento River. Fish screens and ladders, gravel restoration, hatchery expansion, and toxic reduction would be eligible programs.

Many of the specific needs for mitigation are uncertain. Potential impacts requiring mitigation can be identified during studies. Objectives of the Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary, funded in part by the SWP, are to:

- improve understanding of the requirements of fish and wildlife in the estuary;

- develop design and operating criteria for the SWP and CVP for protection and enhancement of fish and wildlife; and

- monitor and evaluate project operations.

These studies provide a sound basis for mitigation measures. For example, the predation control studies in Clifton Court Forebay may reduce losses of Chinook salmon.

The court decision requiring monitoring of Delta channels with the additional pumps also provides mitigation. Mitigation for Delta agricultural needs are identified through studies of leaching practices and the salt tolerance of corn. Continuation of programs to improve water management would provide mitigation by reducing the buildup rate of future upstream diversions and Delta exports.

Since the primary objectives of the North Delta Water Management programs are to reduce reverse flows in the lower San Joaquin River and to reduce fishery impacts, the program should add cumulatively to the Upper Sacramento River Fisheries and Riparian Habitat Management Plan, and could be considered one link in the restoration of salmon and steelhead.

CHAPTER 7. CONSULTATION AND COORDINATION

Environmental Documentation And Public Involvement

The California Department of Water Resources (DWR) prepared this Environmental Impact Report/Environmental Impact Statement (EIR/EIS) for the North Delta Water Management Program (NDP) in compliance with the California Environmental Quality Act and the National Environmental Policy Act (NEPA). This EIR/EIS conforms with both State and federal legal requirements.

The process of environmental review began in early 1987. A Notice of Intent to prepare an EIR/EIS was prepared by USACE and was published in the Federal Register on May 19, 1989. Also in May 1989, a Notice of Preparation was circulated through the California State Clearinghouse and sent to interested parties, and a public notice was issued by USACE

DWR and USACE implemented a public involvement process for the NDP. Public involvement activities include project scoping and public information meetings, and opportunities to comment on both the draft and final EIR/EIS's.

Purpose of Scoping

The Council on Environmental Quality regulations (40 CFR 1500–1508) for implementation of NEPA requires "... an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action. This process shall be termed scoping...." The purposes of the EIR/EIS scoping process were to identify the significant issues for study in the EIR/EIS and to determine the scope of the research of each issues.

Scoping is designed to explore issues for environmental assessment, to ensure that important considerations are not overlooked, and to discover concerns that might otherwise go unrecognized. Through scoping DWR and USACE endeavored to make the EIR/EIS more meaningful and useful to decision–makers and to those affected by the proposals or alternatives.

Scoping Meetings

DWR and USACE held two public scoping meetings in August and September 1987, during which the public and interested agencies identified significant issues related to the NDP. Table A–1 in Appendix A lists the scoping issues ranked by the meeting–1 attendees in order of importance. Table A–2 (Appendix A) lists the scoping issues expressed by the meeting–2 attendees but not ranked in order of importance.

Written Comments

Agencies and organizations also submitted written comments identifying significant issues in response to the public meetings and notices. These are summarized in Table A–3 of Appendix A.

Scoping Report

In February 1989, DWR published a draft scoping report for the NDP. The final report was issued in November 1989. The report describes the planning and environmental documentation process and contains a synthesis of comments received at the scoping meetings and the written comments, copies of written comments, and an analysis of issues.

Ongoing Coordination

Throughout the study period and during preparation of the EIR/EIS, DWR and USACE coordinated and consulted with federal, State, and local agencies. These agencies included:

Federal Agencies

U. S. Bureau of Reclamation
U. S. Environmental Protection Agency
U. S. Fish and Wildlife Service
U. S. Geological Survey
National Marine Fisheries Service
U. S. Coast Guard
U. S. Soil Conservation Service
Advisory Council for Cultural Resources

State Agencies

Department of Fish and Game
Department of Parks and Recreation
Department of Boating and Waterways
State Lands Commission
State Water Resources Control Board

Local Agencies

North Delta Water Agency
San Joaquin County Parks and Recreation
San Joaquin County Department of Public Works
East Bay Regional Park District
East Bay Municipal Utility District
Planning and Conservation League
Metropolitan Water District of Southern California
Sacramento County Department of Public Works
State Water Contractors
California Striped Bass Association
United Anglers
Golden Gate Fishermen Association
California Farm Bureau
Reclamation District 348

Opportunities to Comment on the Draft and Final EIR/EIS's

Agencies, interest groups, and the public will have opportunities to submit written comments on the draft and final EIR/EIS's and to make oral presentations at hearings to be held on the draft EIR/EIS.

Environmental Review and Consultation Requirements

This draft EIR/EIS has been prepared concurrently with environmental review and consultation required by federal environmental law other than NEPA, as required by 40 CFR 1502.25. Compliance with specific environmental review and consultation requirements is described below.

Clean Water Act (33 USC 1251 et seq.)

The Clean Water Act of 1977 aims to "... restore and maintain the chemical, physical, and biological integrity of the Nation's waters." Section 404 of the act establishes a permit program, administered by the U. S. Army Corps of Engineers (Corps), to regulate the discharge of dredged or fill materials into the waters of the United States. Section 401 of the act requires that the project not violate State water quality standards.

Construction of the enlarged Clifton Court Forebay, channel dredging, and installation of barrier-type facilities would require placing fill material into United States waters. This will require a Corps Section 404 permit. DWR will also be requesting project certification from the State Water Resources Control Board to fulfill Section 401. See discussion in Chapter 1 under "Regulatory Permits"

Rivers and Harbors Act of 1899 (USC 401-413)

Section 10 of the Rivers and Harbors Act prohibits the unauthorized obstruction or alteration of any navigable waters of the United States. Increasing the pumping rate at Banks Pumping Plant would require a Corps Section 10 permit. DWR will apply for this permit.

Fish and Wildlife Coordination Act (16 USC 661 et. seq.)

The Fish and Wildlife Coordination Act (FWCA) requires federal agencies to consult with the U. S. Fish and Wildlife Service (USFWS) and the California Department of Fish and Game (DFG) before undertaking projects that control or modify surface water. This consultation is intended both to promote the conservation of wildlife resources by preventing loss of or damage to wildlife resources and to provide for the development and improvement of wildlife resources in connection with water projects. Federal agencies undertaking water projects are required to include in project reports recommendations made by the USFWS and DFG, to give full consideration to these recommendations, and to include in project plans justifiable means and measures for wildlife purposes.

The USFWS and DFG have been extensively involved in this project from the start. USFWS lead the Habitat Evaluation Procedures (HEP) team consisting of representatives from USFWS, DFG, USACE, and DWR. USFWS prepared a draft report on impacts and compensation needs analysis using HEP in October 1990. Negotiations are continuing on the HEP, and an agreement should be reached by all agencies before the final EIR/EIS. A preliminary draft FWCA report on impacts from the project and recommended compensation measures to mitigate for the impacts is currently under review. The FWCA report will be included in the final EIR/EIS.

Endangered Species Act (16 USC 1531 et. seq.)

Section 7 of the Endangered Species Act (ESA) of 1973 requires federal agencies, in consultation with the Secretary of the Interior, to ensure that their actions do not jeopardize the continued existence of endangered or threatened species, or result in the destruction or adverse modification of the critical habitat of these species.

USFWS prepared a list of threatened, endangered, and candidate species which may occur in the project area. As discussed in Chapter 3, DWR and USACE had field surveys conducted for these species in 1987 and 1988. As negotiations for definition of the proposed action near completion, a biological assessment will be prepared to determine whether any listed species or species proposed for listing are likely to be affected by the proposed action. This assessment will be submitted to USFWS, the National Marine Fisheries Service (NMFS) and DFG with a request for formal consultation if the proposed action would affect listed species. Subsequently, USFWS, NMFS, and DFG would prepare a Biological Opinion to determine whether the action would jeopardize the continued existence of listed species or adversely modify their critical habitat. If a finding of jeopardy or adverse modification is made in the Biological Opinion, DWR would have to modify the project to ensure listed species are not affected.

National Historic Preservation Act (16 USC 470 et. seq.)

Section 106 of the National Historical Preservation Act (NHPA) requires federal agencies to evaluate the effects of federal undertakings on historical, archeological, and cultural resources. Agencies are required, within the vicinity of proposed projects, to identify historical or archeological properties, including properties on the National Register of Historic Places, and those that the agency and the State Historic Preservation Office (SHPO) agree are eligible for listing in the National Register. If the federal project is determined to have an adverse effect on National register properties or those eligible for listing, the agency is required to consult with the SHPO and the Advisory Council on Historic Preservation to develop alternatives or mitigation measures to allow the project to proceed.

Coordination for a Class II cultural resources survey through USBR is in process. When the results are analyzed, it will be determined whether a more extensive Class III survey is necessary. A cultural resources report will be prepared and sent to the SHPO. If it is determined that adverse effects will occur, the procedure described in the previous paragraph will be followed.

Farmland Protection Act (16 USC 590 a–f,q)

Council on Environmental Quality memoranda to Heads of Agencies, dated August 30,1976, and August 11, 1980 and the Farmland Protection Act of 1981 require agencies in their EIS's to include farmlands assessments designed to minimize adverse impacts on prime and unique farmlands. The regulations published in the Federal Register (Vol. 49, No. 130, July 5, 1984) contain the criteria to be used to identify these lands and determine impacts. As negotiations for definition of the proposed action near completion, the Soil Conservation Service will be contacted to identify whether the proposed action will affect any lands classified as prime and unique farmlands. If any lands are identified, alternatives would be considered which could lessen impacts to such lands.

Executive Order 11988: Floodplain Management

Executive Order 11988 requires federal agencies to prepare floodplain assessments for proposals located within or affecting floodplains. If an agency proposes to conduct an action within a floodplain, it must consider alternatives to avoid adverse impacts and incompatible development in the floodplain. If the only practicable alternative involves siting in a flood plain, the agency must minimize potential harm to or within the floodplain.

The north Delta lies within the floodplain. Therefore, the NDP facilities are located in the floodplain. Modification to existing levees would enlarge north Delta channel cross–sections and hence increase channel capacity. With increased capacity, the channels would be able to contain greater floodflows and provide greater protection from flooding. New levees would also be designed to meet 100–year flood standards.

Executive Order 11990: Protection of Wetlands

Executive Order 11990 requires federal agencies to prepare wetlands assessments for proposals located within or affecting wetlands. Agencies must avoid undertaking new construction located in wetlands unless no practical alternative is available and the proposed action includes all practicable measures to minimize harm to wetlands. The NDP will not impact any natural occurring wetlands. See discussion in Chapter 5, under "Impacts on Wetlands."

Clean Air Act (42 USC 7501)

Section 176 (c) of the Clean Water Act requires that no federal agency, "... (1) engage in, (2) support in any way or provide financial assistance for, (3) license or permit, or (4) approve, any activity which does not conform to a plan after it has been approved or promulgated under Section 110." A "plan" refers to a State Implementation Plan (SIP) to meet the National Ambient Air Quality Standards (NAAQS) that is approved by the Administrator of the Environmental Protection Agency (EPA). Each approved SIP must contain a clear definition of the circumstances in which a federally funded or approved project will or not conform to the SIP. If there is no approved SIP, EPA is responsible for determining compliance with the Clean Air Act and whether or not a project will affect future abilities to meet the NAAQS. In either case, providing the information necessary for a determination of conformity is an agency responsibility. SIP's are required for any area whose present ambient air quality does not meet the NAAQS.

To show conformity with the NAAQS, a federal agency proposing an action must show that the proposal will not cause violations of the NAAQS or in any way hinder future attainment of the NAAQS. This can be done by demonstrating that the proposed action does not induce growth which would prevent or hinder compliance with the NAAQS, showing that growth projections used in the air-quality analysis are in accordance with projections in an approved SIP, or mitigate increased pollutants which would result form a proposed action.

The NDP will not have any growth-inducing impacts and, hence, will comply with the NAAQS. The growth-inducing impact analysis is discussed in Chapter 5.

Distribution List

1. The following represents distribution of the document:

a) **U. S. Department of the Interior:**
Bureau of Reclamation, Sacramento
Bureau of Land Management, Sacramento
Fish and Wildlife Service, Portland; Sacramento (2)
Geological Survey, Sacramento; Menlo Park
National Park Service, San Francisco (2)
Regional Environmental Officer, DOI, San Francisco

b) **Other Federal Agencies:**
Advisory Council on Historic Preservation
Department of Agriculture
Department of Energy
Department of Transportation
Environmental Protection Agency, San Francisco (3)
Federal Emergency Management Agency, San Francisco
Forest Service, San Francisco
Federal Highway Administration, San Francisco
National Marine Fisheries Service,
Soil Conservation Service, Davis
Western Area Power Administration, Sacramento

c) **United States Senate, Washington D.C.:**
Honorable Alan Cranston
Honorable Pete Wilson

d) **United States House of Representatives, Washington D.C.:**
Honorable Tom Campbell
Honorable Ronald V. Dellums
Honorable Don Edwards
Honorable Vic Fazio
Honorable Robert Matsui
Honorable Tom Lantos
Honorable George Miller
Honorable Norman Y. Mineta
Honorable Nancy Pelosi
Honorable Fortney H. (Pete) Stark

e) **State Agencies (State of California):**
Air Resources Board, Sacramento
Assembly Committee on Agriculture, Sacramento
Assembly Committee on Water, Parks, and Wildlife, Sacramento
Assembly Natural Resources Committee, Sacramento
Board of Aeronautics, Sacramento
California Highway Patrol, Napa
California Water Commission, Sacramento
Chamber of Commerce, Sacramento
Department of Boating and Waterways, Sacramento
Department of Conservation, Sacramento
Department of Fish and Game, Sacramento (4)
Department of Food and Agriculture, Sacramento
Department of Forestry, Sacramento, Spanish Flat Station (2)
Department of General Services, Sacramento
Department of Health Services
Department of Parks and Recreation, Sacramento
Department of Transportation, Sacramento
Department of Water Resources, Sacramento
Native American Heritage Commission, Sacramento
Office of Governor Deukmejian, Sacramento
Office of Historic Preservation Sacramento
Regional Water Quality Control Board, Central Valley Region, Sacramento
State Clearing House, Sacramento (20)
State Lands Commission, Sacramento
State Reclamation Board, Sacramento
State Water Resources Control Board, Sacramento
Wildlife Conservation Board, Sacramento

f) **Local Agencies:**

Bacon Island, RD 2028
Bishop Tract, RD 2042
Bouldin Island, RD 756
Brack Tract, RD 2033
Bradford Island, RD 2059
Brannan–Andrus LMD (RD 317, 407, and 2067)
Byron Tract, RD 800
Canal Ranch Tract
Central Delta Water Agency
City of Lodi

City of Sacramento
Coney Island, RD 2117
Contra Costa County
Contra Costa County Water Agency
Contra Costa Water District
Deadhorse Island, RD 2111
Fabian Tract, RD 773
Grand Island, RD 3
Holland Tract, RD 2036
Hotchkiss Tract, RD 799

Jersey Island, RD 830
Kings Island, RD 2044
Libby McNeil, RD 369
Mandeville Island, RD 2027
McCormack–Wiiliamson Tract, RD 2110
McDonald Island, RD 2030
Medford Island, RD 2041
Merrit Island, RD 150
Middle Roberts Island Reclamation District 524
Mildred Island, RD 2021

New Hope Tract
North Delta Water Agency
Orwood Tract, RD 2024
Pierson District, RD 551
Pacific Gas and Electric Company
Paradise Junction, RD 2095
Reclamation District 348
Palm Tract, RD 2036
Pescadero District, RD 2058
Pico and Nagle, RD 1007

Quimby Island, RD 2090
Randall Island, RD 755
Rindge Tract, 2037
Rio Blanco Tract, RD 2114
River Junction, RD 2064
Rough and Ready Island, RD 403
Sacramento County, RD 1002
San Joaquin County, RD 548
San Joaquin County, RD 2074
Sherman Island, RD 341

Stark Tract, RD 2089
Staten Island, RD 38
Stewart Tract, RD 2062
Terminous Tract, RD 548
Twitchell Island, RD 1601
Tyler Island, RD 563
Union Island, RD 1, 2
Upper Andrus Island, RD 556
Upper Jones Tract, RD 2039
Upper Roberts Island, RD 544

Veale Tract, RD 2065
Venice Island, RTD 2023
Victoria Island, RD 2040
Walnut Grove, RD 554
Webb Tract, RD 2026
Weber Tract, RD 828
Woodward Island, RD 2072

g) **Organizations:**

Association of California Water Agencies, Bay Institute of San Francisco, Boyle Engineering, Brown and Caldwell, California Trout, California Striped Bass Association,California Wildlife Federation, California Waterfowl Association, CH2M Hill, Defenders of Wildlife, Environmental Council, Environmental Defense Fund, Friends of the River, Grizzly Island Wildlife Area, Izaak Walton League of America, League of Women Voters of California, Marin Conservation League, Marine Research Center, Montgomery Engineers, Inc., Natural Defense Council, Oceanic Society, Pacific Interclub Yacht Association, Planning and Conservation League, Recreational Boaters of California, San Francisco Bay Conservation and Development Commission, Sacramento Audubon Society, Salmon Unlimited, Sierra Club, Save San Francisco Bay Association, Association of State Water Contractors, Stockton Audubon Society, The Nature Conservancy, United Anglers of California, Murray Burns & Kienlen, Woodward–Clyde Consultants, San Joaquin River Water Users Association

h) Individuals:
Harvey O. Banks, Brian Bell, Dante J. Nomellini, William E. Warne, John L.Winther, Ken Woodward, Frederick Bold Jr., Max Bookman, D.W. Kelley, Ann Schneider, George Basye, Gerald Orlob, John W. Pulver, Tony Klein, Robert Krieger, Richard Dornhelm, Gwen Buchholz, Joseph I. Burns, Harold Rogers, Jr., Richard L. Schafer, Michael Smith, Thomas M. Stetson, Dorothy Green, Victor Viets, Art Miller B.J. Miller, Tom Mongan, Robert Mygrant, John Gregg, Bert Parkinson, Sally Freedman, G.F. Shuster III, Marvin Sternberg, Allen Zacharias.

i) Media:
Los Angeles Times, Record Searchlight, San Francisco Chronicle, Tracy Press, San Bernardino Sun, Fresno Bee, Times-Standard, Sacramento Bee, Sacramento Union.

j) State Senate:
Honorable John Doolittle
Honorable John Garamendi
Honorable Leroy Greene
Honorable Barry Keene
Honorable James Nielsen

k) State Assembly:
Honorable Chris Chandler
Honorable Lloyd Connelly
Honorable Thomas Hannigan
Honorable Bev Hansen
Honorable Dan Hauser
Honorable Phillip Isenberg
Honorable Patrick Johnston
Honorable Tim Leslie
Honorable Stan Statham
Honorable Norm Waters

APPENDIXES

Note: Some of the appendixes to the North Delta Program Environmental Impact Report/Statement are too long to be included in this document. The information in these appendices has been abbreviated in the EIR/EIS and summarized here. Readers wishing to consult the full appendixes for more detailed information should contact the Department of Water Resources, Division of Planning, Sacramento, California for locations where the appendixes are available for public review.

A. Glossary and Abbreviations

B. Scoping Meeting Issues and Comments

C. Modeling Assumptions and Results

D. NDP Biological Assessment

E. Economic Analysis Summary

F. Direct Fish Impact Analysis Summary

G. U.S. Fish and Wildlife Service's Coordination Act Report Summary

H. Construction Report Summary

I. Preliminary Dredge Material Test Results

J. Seismic Report Summary

K. Archeological Report Summary

L. Recreation Report Summary

M. Narrowing of Alternatives

N. Documents Incorporated by Reference

O. List of Preparers

P. Wetland Inventory and Analysis

APPENDIX A
GLOSSARY AND ABBREVIATIONS

APPENDIX A
GLOSSARY AND ABBREVIATIONS

ABBREVIATIONS

AF	-	acre-foot
APCD	-	Air Pollution Control District
BTU	-	British thermal unit
CALOSHA	-	California Occupational Safety and Health Administration
Caltrans	-	California Department of Transportation
CCC	-	Contra Costa Canal
CCF	-	Clifton Court Forebay
CCWD	-	Contra Costa Water District
CEQA	-	California Environmental Quality Act
CFS	-	cubic feet per second
CIMIS	-	California Irrigation Management Information System
CNDDB	-	California Natural Diversity Data Base
COA	-	coordinated operating agreement
Corps	-	United States Army Corps of Engineers (also USACE)
CPUE	-	Catch per unit effort
CUWA	-	California Urban Water Agencies
CVP	-	Central Valley Project
CY	-	Cubic Yard
DAPC	-	Delta Advisory Planning Council
DFG	-	Department of Fish and Game
DMC	-	Delta-Mendota Canal
DWR	-	Department of Water Resources
DWOPER	-	dynamic wave operational model
DWRSIM	-	Department of Water Resources' statewide water simulation model
EBMUD	-	East Bay Municipal Utility District
EC	-	electrical conductivity
EIR	-	Environmental Impact Report
EIS	-	Environmental Impact Statement
EPA	-	Environmental Protection Agency
ESA	-	Endangered Species Act
ET	-	evapotranspiration
FEMA	-	Federal Emergency Management Agency
FWCA	-	Fish and Wildlife Coordination Act
FWS	-	Fish and Wildlife Service (also USFWS)
GAC	-	granular activated carbon
GWh	-	gigawatt hours
HEP	-	habitat evaluation procedure
HSI	-	habitat suitability index
HUs	-	habitat units
IDC	-	Interagency Delta Committee
IDHAMP	-	Interagency Delta Health Aspects Monitoring

Program

KCWA - Kern County Water Agency
KWB - Kern Water Bank
kWh - kilowatt-hour
LADWP - Los Angeles Department of Water and Power
LBG - Los Banos Grandes
M&I - municipal and industrial
MAF - million acre-feet
MCY - million cubic yards
MLLW - mean lower low-water
MMWD - Marin Municipal Water District
MSL - mean sea level
MW - megawatt
MWD - Metropolitan Water District of Southern California
NAAQS - National Ambient Air Quality Standards
NBA - North Bay Aqueduct
NDP - North Delta Program
NDWMP - North Delta Water Management Program
NEPA - National Environmental Policy Act
NFIP - National Flood Insurance Program
NGVD - National Geodetic Vertical Datum (1929)
NHPA - National Historical Preservation Act
NMFS - National Marine Fisheries Service
NOI - notice of intent
NOP - notice of preparation
OWC - Office of Water Conservation
PG&E - Pacific Gas and Electric Company
PPB - parts per billion
PPM parts per million
Reclamation - United States Bureau of Reclamation (also USBR)
Regional Board - Regional Water Quality Control Board (also RWQCB)
RMA - Resource Management Associates
RWCQB - Regional Water Quality Control Board (also Regional Boar
RO - reverse osmosis
SCS - United States Soil Conservation Service
SDWA - South Delta Water Agency
SDWMP - South Delta Water Management Program
SF - square feet
SFEP - San Francisco Estuary Project
SHPO - State Historic Preservation Office
SIP - State Implementation Plan
SJVDP - San Joaquin Valley Drainage Program
SRI - Sacramento River index
SWP - State Water Project
SWRCB - State Water Resources Control Board
TAF - thousand acre-feet

TDS	–	total dissolved solids
THMFP	–	trihalomethane formation potential
THMs	–	trihalomethanes
USACE	–	United States Army Corps of Engineers (also Corps)
USBR	–	United States Bureau of Reclamation (also Reclamation)
USFWS	–	United States Fish and Wildlife Service (also FWS)
USGS	–	United States Geological Survey
WDRA	–	water delivery risk analysis
WDWMP	–	West Delta Water Management Program
YCWA	–	Yuba County Water Agency

GLOSSARY

California Aqueduct - The major conveyance facility of the State Water Project which carries water from the Sacramento-San Joaquin Delta to as far south as Lake Perris in Southern California.

Carriage Water - Additional Delta outflow, over and above the basic outflow required to meet water quality standards of State Water Resources Control Board's 1978 Water Rights Decision 1485. The additional Delta outflow required (carriage water) is a function of Delta export pumping and south Delta inflow and is necessary to control sea water intrusion into the Delta. Carriage water will not be required with a Cross Delta facility.

Critical Period - The most severe extended dry period of recorded historic hydrology which would create the greatest demand on a water supply system. Often used as a criteria for design of water supply facilities.

CVP-SWP Sharing Formula - A formula or method of shared responsibility for water usage in the Sacramento Valley region, shared responsibility for the maintenance of Delta water quality standards and for the sharing of unstored river flows between the CVP and the SWP for purposes of export from the Delta.

D-1485 - State Water Resources Control Board Water Right Decision 1485 of August, 1978 which sets forth water quality and flow standards for the Sacramento-San Joaquin Delta and Suisun Marsh.

Delta Exports - Water that is exported from the Sacramento San Joaquin Delta which includes water from the North Bay Aqueduct, the Contra Costa Canal and water pumped at the Delta and Tracy Pumping plants.

Delta Outflow Criteria - Minimum water quality or flow standards for the Sacramento-San Joaquin Delta and Suisun Marsh such as those required by D-1485.

Depletion Studies - Studies used to estimate the effects of a given projected level of development on an historic streamflow base.

Diversions - Water diverted at a control point such as a reservoir control point. Diversions typically represent basin irrigation diversions, water transfers, municipal diversions and exports.

Fish Flows - Instream flows or reservoir releases which must be maintained to protect or enhance fishery resources.

Historic Hydrology - Actual measured river flows from which present and future hydrologic conditions may be derived. Such flows are adjusted to account for changes over time due to native vegetation, agriculture, operation of municipalities and the operation of nonproject reservoirs.

Navigation Flows - River flows which are required to maintain adequate channel depth to provide for waterway navigation.

No Action - In this report, this is equivalent to "No Project" under CEQA and NEPA, meaning that the proposed program, including physical works, management strategies and related mitigation measures are not implemented.

Optimization - The mathematical technique of determining the optimal solution to a physical process. Typically used in water delivery systems to maximize benefits of water deliveries or to minimize costs or risks.

Return Flows - Flow returned to a stream channel following municipal, industrial or agricultural withdrawal and use.

Rule Curve - Operations criteria formulated to determine how to best operate the SWP system in order to maximize water deliveries within the framework of greatest economic benefit and while retaining sufficient water in reservoir storage facilities to protect against future shortages.

Upstream Depletions - Depletions which occur upstream from the Sacramento-San Joaquin Delta. (See Depletion Studies)

Yield - A quantity of water delivered annually to a service area from a water project on a specified delivery schedule. The SWP minimum project yield refers to the yield (assuming certain allowable deficiencies) when the system is simulated through the critical dry period of record.

APPENDIX B
SCOPING MEETING ISSUES AND COMMENTS

APPENDIX B
SCOPING PROCESS

Scoping sessions were conducted on August 25, 1987 in Walnut Grove and on September 11, 1987 in Sacramento to solicit public input in determining the scope of the EIR/EIS and significant issues related to the alternatives identified. A February 1989 report—*North Delta Water Management Project, A Draft Report on Public Involvement and Identification of Issues,* prepared by the Department of Water Resources—discussed the planning and environmental documentation process and findings of the scoping meetings.

Issues and questions identified at the first public scoping session were scored on the basis of frequency and relative ranking of each issue raised. Table A-1 shows the scoping issues by rank. Table A-2 shows the issues and questions identified at the second public scoping session, not ranked. Various federal and State agencies and private citizens sent letters identifying a number of issues. Written comments are summarized in Table A-3.

Table B-1
MEETING 1. (WALNUT GROVE) SCOPING ISSUES, LISTED BY RANK

Rank	Issue	Score*
1	Extend South Fork Mokelumne dredging northeast to I-5.	15
2	Extend South Fork Mokelumne dredging south to San Joaquin River.	14
3	Include effects of increased runoff from urban development of the Morrison and Laguna Creek areas.	14
4	Expedite Phase I due to Morrison Creek Project.	13
5	Due to downstream impacts of USACE Lambert Road improvement work (Morrison Stream Group), DWR South Fork Mokelumne channel improvements should be done first).	9
6	Coordinate FEMA requirements and subventions work with levee setbacks.	9
7	Develop study on Phase I only. Incorporating later phases would make Phase I much less likely to be supported.	8
8	Consider water storage in areas of origin (before entering Delta).	8
9	DWR should request halting upstream flood control projects which would negatively impact South Fork Mokelumne flood stages.	6
10	Conduct a flood study on the entire Delta.	4
11	Increase height of gates on Delta Cross Channel. They were observed to over top during the February 1986 flood.	3
12	Enlargement of South Fork Mokelumne River should lower 100-year flood stages by more than 10 percent estimated by DWR. This should be studied further.	2
13	Determine whether any phases of the project could be implemented without legislation.	2
14	Connecting channel has high political sensitivity.	2
15	Investigate flow and quality conditions downstream of proposed wingwalls on Sacramento River	2
16	Study effects of wingwall structures on levee freeboard during flood flows.	2
17	Evaluate effects on Beaver, Hog, and Sycamore Sloughs and whether they should be dammed.	2
18	Existing hydraulic studies do not account for surge effects.	1
19	Study should consider revegetation of levees.	1
20	Evaluate salinity effects of wingwall structures.	1
21	Investigate partial and full salinity control barriers at Chipps Island.	1
22	Consider Beaver, Hog, and Sycamore Sloughs for wildlife mitigation areas.	1
23	Guarantee of THM reduction.	0
24	Examine project effects on water quality for Contra Costa and South Delta exports.	0
25	Determine operation and maintenance costs for the project.	0
26	Determine if Delta Cross Channel should be improved.	0
27	Severity of flooding in this area is historically documented.	0

*The score represents the number of times the issue was ranked in the top five by meeting participants on questionnaires (See Appendix A, Attachment 3).

Table B–2
MEETING 2. (SACRAMENTO) SCOPING ISSUES, NOT RANKED

1. Investigate barriers at Chipps Island.
2. Consider interaction between Federal and State agencies.
3. Investigate relationship of proposed project to EBMUD diversions from the American River.
4. Integration of north Delta Phase I and Phase II as one project.
5. Include major structural alternatives, such as a peripheral canal of various sizes.
6. Consider alternative water supplies.
7. Include various levels of flood control protection in the analysis.
8. Don't construct anything without immediate benefit to fisheries; use no artificial means.
9. Give earthquake potential high consideration in evaluating flood protection.
10. In planning recreation facilities, consider less asphalt paving.
11. Consider flood control in areas of flood flow origin.
12. Consider additional upstream flood control.
13. Store flood flows in area of origin, assess water quality benefits.
14. Consider flood control in urban areas upstream from Delta.
15. Project is more than a water supply project.
16. Flood control is worthwhile project objective.
17. Renegotiation of Two–Agency Fish Agreement if exports are increased.
18. Increase draft of fish from Sacramento River to the Mokelumne River could affect the winter run of salmon.
19. Consider wildlife effects from levee setbacks and channel enlargement and consider effects on riparian habitat.
20. Examine all alternatives.
21. Develop agreement on mitigation options prior to implementation of any plan.
22. Try to eliminate reverse flows.
23. Impacts of project on wetlands upstream (Morrison Stream Group).

Table B-3
SUMMARY OF WRITTEN COMMENTS

California Department of Fish and Game

1. Maintain integrity of the Wildlife Conservation Board island on the South Fork Mokelumne River and Sycamore Slough (DFG 7-28-87). This island is currently a wildlife refuge.
2. Coordinate with DFG to evaluate the impacts of the project on threatened and endangered species (DFG 7-28-87).
3. Evaluate the impacts of increased diversions from the Sacramento River on the winter run of chinook salmon (DFG 7-28-87).
4 Evaluate the impact of the north Delta proposal on the agreement between DWR and DFG to offset direct fish losses in relation to the Harvey O. Banks Delta Pumping Plant (DFG 7-28-87).
5. DWR must consider stipulations of CEQA and Davis-Dolwig Act. specifically, streambed alterations and fish screen issues (DFG 7-28-87).
6. Project will require a new agreement for protecting fisheries in relation to the Harvey O. Banks Pumping Plant (DFG 9-11-87).
7. More diversions from the Sacramento River will draw more fish from their normal migratory routes. Fish screens may be required by Section 6100 of the Fish and Game Code (DFG 9-11-87).
8. Levee improvements and levee setbacks must not lead to loss of wildlife habitat or wintering wildlife food production (cropland) (DFG 9-11-87).
9. North and south Delta projects are linker together from a fish and wildlife perspective and must be analyzed that way (DFG 9-11-87).
10 Project description is lacking in detail, therefore, it is not possible at this time to provide comprehensive comments on the project. (DFG 6-16-89).
11. Include measures to offset fisheries and wildlife resource impacts due to increased diversion of the SWP (DFG 6-23-89).
12. Maintain early and close coordination to incorporate fish and wildlife resource protection provisions called for in SB 34. (DFG 6-23-89).
13. Examine impact of SWRCB D-1485 hearings on project and its objectives (DFG 6-23-89).
14. Recognize the interrelationship of the South and North Delta Water Management Project (SDWMP and MP, respectively). Evaluate impacts accordingly (DFG 6-23-89). NDW
15. State Fish and Game Commission has determined that the winter-run chinook salmon should be listed as an endangered species. DWR should consult with DFG, and USACE with USFWS. (DFG 6-23-89).
16. Analyze and describe the changes in Delta conditions due to the NDWMP and the SDWMP. State effect on resident and anadromous fish (DFG 6-23-89).
17. Define changes in upstream reservoir operations. State effects on fisheries and wildlife resources (DFG 6-23-89).
18. Estimate the direct loss of fish at the SWP and CVP pumping facilities (DFG 6-23-89).
19. Explore alternatives that minimize impacts to wetland and wintering wildlife habitat. List impacts and mitigation measures for wetlands on existing berm islands (DFG 6-23-89).

Table B-3 (Continued)

U. S. Fish and Wildlife Service

1. Discuss the importance of State/Federal Water Project yield improvement as an objective in this program (USFW 9-17-87).
2. Alternative means to increase water supply should be considered (USFW 9-17-87).
3. Detailed operational and institutional descriptions should be provided.
4. Analyze the present and future impacts of pumping operations on present and future Bay-Delta water quality standards (USFW 9-17-87).
5. Impacts to all riparian habitats should be fully described and appropriate mitigation measures should be identified (USFW 9-17-87).
6. Impacts of upstream wetland areas from less frequent flooding due to project improvements down stream (Stone Lakes area) (USFW 9-17-87).
7. Analysis of benefits and detriments to all fisheries (especially anadromous fish) (USFW 9-17-87).
8. USBR's role in the project (CVP operation impact) (USFW 9-17-87).
9. Impacts of both Phase I and II should be fully analyzed (USFW 9-17-87).
10. Process must include effects of project on endangered species list (USFW 10-2-87).
11. All mitigation measures listed in memorandum dated 8-30-88 are applicable except planning goal for shaded riverine aquatic cover has been modified (USFW 6-15-89).
12. Consider placing dredge spoils along the waterside of existing banks to establish riparian vegetation (USFW 6-15-89)
13. USFW is preparing a list of endangered species affected by changes in the construction area (USFW 6-15-89).
14. Consider the increase of fish entrainment at the SWP and CVP pumping plants (USFW 6-15-89).
15. To make recommendations to mitigate adverse fisheries effects, detailed operations in the Delta must be known (USFW 6-15-89).
16. Writing one EIR/EIS would clarify interrelations of all Delta projects (USFW 6-15-89).
17. Recommend against issuance of a permit until operation studies and other data are provided (USFW 6-15-89).

Planning and Conservation League

1. Look at impacts of all diversions from the Delta and analyze alternatives (CVP, SWP, EBMUD, Contra Costa Aqueduct, North Bay Aqueduct) (PCL 9-11-87).
2. Analyze the purpose and need for partial tide gate structures Impact on fish, navigation, wildlife and aesthetics (PCL 9-11-87).
3. EIR/EIS should analyze all phases of project including possible construction of new channels (PCL 9-11-87).
4. EIR/EIS should consider all alternatives that may be implemented in the future. alternatives like New Hope Cross Channel and various stages of the Peripheral Canal (PCL 9-11-87).
5. EIR/EIS should address protection of all spawning, migratory and habitat areas for fishery (PCL 9-11-87).

Table B-3 (Continued)

6. EIR/EIS must analyze other options available to enhance the SWP efficiency other than increased diversions from the Delta (water banking, offstream storage, Colorado River) (PCL 9-11-87).
7. All feasible alternate means of flood control must be analyzed such as flood-proofing, levee rehabilitation, flood plain rezoning (PCL 9-11-87).
8. Water quality analysis for each alternative should be conducted to help determine feasibility of the alternative (PCL 9-11-87).
9. The project, as planned, would devastate the vitally important fisheries of the San Francisco Bay-Delta Estuary (PCl 6-23-89)
10. Consider alternatives to water supply: urban and agricultural wastewater reclamation, transfer of already developed water supplies to other users, using Delta islands as storage facilities, pricing mechanisms to encourage conservation, ground water recharge, constructing isolated Delta water conveyance in a canal or buried pipeline (PCL 6-23-89).
11. Fisheries and Wildlife: changing export schedule to reduce adverse impacts, improving screens on CVP/SWP pumping plants, altering flow from upstream reservoirs to improve anadramous fisheries, isolated channel (PCL 6-23-89).
12. Flood Control: only implement Phase I, alter upstream reservoir flow, enhance wetlands by using additional upstream acreage for diversion of high water flows (PCL 6-23-89).
13. Water Quality: reduce the discharge of pollutants, provide additional drinking water treatment facilities, improve operations of San Luis Reservoir, provide other isolated facilities (PCL 6-23-89).
14. Cumulative Impacts: relation of project to: lower San Joaquin River Clearing and Snagging Project, proposals to enlarge channels in the south Delta, proposals to enlarge Clifton Court Forebay, USBR plans to market additional water to CVP users, area of origin increased water diversions from the Delta, additional flood control projects and potential losses of riparian and fisheries habitat, Delta levee construction and others (PCL 6-23-89).

Contra Costa County

1. EIR/EIS must address the effects of water quality on western Delta islands due to north Delta modifications (CCC 10-1-87).
2. Analyze the effects of changing flow patterns on fishery (CCC 10-1-87).
3. Analyze the impact on the entire Bay/Estuary of increased water exports from the Delta (CCC 10-1-87).

Defenders of Wildlife

1. EIR/EIS should include comprehensive information on endangered species, fisheries, wetlands, riparian forests and other natural values that may be affected by the project. DOW opposes any alternative which would further harm these resources (Defenders of Wildlife 9-14-87).

Downey, Brand, Seymour, and Rohwer Law Offices

1. Flooding in the Stone Lake area is being aggravated by development upstream and raising levees downstream. The County's proposed Lambert Road improvements should be completed, and needs of the Stone Lake area residents should be considered (DBS&R 9-24-87).

Stockton Audubon Society

1. Project impacts on riparian forests must be considered. These are extremely important habitat, including areas of regrowth after clearing levees (SAS, 8-25-87).

Table B-3 (Continued)

2. Marshy areas, created by seasonal flooding, are very important to wintering waterfowl. Project impacts on marshes must be considered (SAS, 8-25-87).
3. Preservation of water quality is very important (SAS, 8-25-87).

Betty Kuhn

1. Evaluate flooding due to backwater from Mokelumne River and alternatives for river clearing and levee improvement (BK 8-18-87).
2. Evaluate flood inducing impact of development in Laguna Creek area and barrier effect of I-5 in exacerbating flooding on Circle K Ranch (BK 8-18-87).

U. S. Coast Guard

1. Evaluate impact on clearances for navigation at bridges, wingwall structures, and floodgates (USCG 8-11-87).

U.S Department Of Commerce

1. Recommend withholding of a permit, without prejudice for the project, pending completion of EIS (USDOC 6-16-89).
2. Do not object to issuance of permit (USDOC 6-20-89).

U.S. Department Of The Interior, Bureau Of Reclamation

1. Designate USBR as a cooperating agency in the preparation of the subject EIR/EIS. USBR will evaluate the effects of the project on the CVP (USBR 6-28-89).
2. USBR has contracted out the field studies and report for threatened and endangered species (USBR 6-28-89).

Department Of Health And Human Services

1. Consider the USPHS Public Health and Safety Concerns (DHHS 6-14-89).

USACE – Internal Memos

1. Completion of proposed projects will change the elevations of the 100 yr flood plain in the area. Re-study for flood insurance (FPM Branch 5-26-89).
2. Projects may be incorporated into the corps feasibility study (SP STUD. Branch 5-26-89).

California Department Of Transportation

1. Proposed work should not subject the area's structures to any additional flood risk, but could alter the degradation potential of the waterways at these structures (Caltrans/Structures 5-30-89).
2. Reviewed NOP, no comments (Caltrans/Stockton 6-14-89).

State Lands Commission

1. Effects of project on public trust values: recreation, wildlife and fisheries resources, and riparian vegetation, within the project area and upstream and downstream on the channel modifications (SLC 6-20-89).

Table B-3 (Continued)

2. Discuss impacts on public trust values due to changes in operation of SWP and CVP pumping plants and upstream reservoirs. (SLC 6-20-89).
3. Consult SLC before acquisition of land. Many areas involve present or historic tide or submerged lands, and are therefore sovereign (SLC 6-20-89).

The Reclamation Board

1. Section 8710 of the California Water Code requires DWR to obtain a Reclamation Board permit prior to construction.

State Water Resources Control Board

1. Recommend preparing a programmatic EIR (SWRCB 6-2-89).
2. Regional boards have jurisdiction over the disposal of dredge spoil materials that could affect water quality (SWRCB 6-2-89).

California Regional Water Quality Control Board

1. Evaluate impacts on surface and groundwater from disposal activities. Sample and analyze to identify the types and levels of constituents of potential concern (CRWQCB 6-12-89).
2. Minimize turbidity and entrainment of sediment in downstream waters as a criterion for acceptability (CRWQCB 6-12-89).

Department Of Parks And Recreation – Office Of Historical Preservation

1. USACE must comply with section 106 of the National Historic Preservation Act and 36 CFR 800. Consider potential effects to archeological or historical resources (DPR 5-9-89).
2. To allow complete review by OHP, provide the information requested (DPR 5-9-89).

Brack Tract Reclamation District No 2033

1. The reclamation district would like the opportunity to provide input (BTRD 5-30-89).
2. Would like to meet with DWR to explain concerns (BTRD 5-31-89).
3. East of Thornton there are over three miles of nonmaintained levee. Breaks could affect North Delta area. (BTRD 8-1-89).
4. The project will affect water levels in Hog and Sycamore sloughs. This may impose on water rights. (BTRD 8-1-89).
5. Work is scheduled to start upstream and work downstream. This may cause a bottle neck with water backing up during the project (BTRD 8-1-89).
6. Dredging may undermine levees (BTRD 8-1-89).
7. Deepening the river will increase seepage into the adjacent property (BTRD 8-1-89).

Reclamation District No. 341 – Sherman Island

1. Examine the possibility of salt water intrusion due to reduced flow (RD341 5-25-89).
2. Determine if reduced flows to the delta will cause flooding problems elsewhere (RD341 5-25-89).

County Of Sacramento – Environmental Management Department

1. Assess possible ramifications of the dredging disposal. Analyze dredged material for proper disposal. This may require a classification determination from the Dept. of Health Services (CoS 6-27-89).

Table B-3 (Continued)

County Of Sacramento – Department Of Parks And Recreation

1. Examine impacts on water levels, wildlife, fisheries, and recreation in the county's proposed wildlife refuge areas (CoS 6-7-89).

Environmental Defense Fund

1. New standards should be set to increase freshwater flow for the Bay/Delta system (EDF 6-20-89).
2. Assess the cumulative impacts, specifically the adverse effects of water diversions by state, federal and local projects (EDF 6-20-89).
3. A programmatic EIS is called for due to the cumulative nature of the several activities being under taken by the department which, taken together, constitute a single program for construction of Delta water conveyance facilities (EDF 6-20-89).
4. Evaluate non-structural water supply alternatives, e.g., transfer of conserved water from existing users to new users (EDF 6-20-89).
5. Consider economic impact on sport and commercial fisheries, tourism, recreation, property values and other interests. Explain how the proposed project will be financed (EDF 6-20-89).
6. Impacts to striped bass will be reduced as a result of directing flow away from nursery areas. Consider impacts of diverting a larger number of Sacramento River striped bass eggs, larvae, and adults into the area (EDF 20-89).
7. Examine temperature impacts on out-migrating salmon smolts of reduced Sacramento River flow (EDF 6-20-89).
8. Evaluate impact of reduced flow on migrating shad (EDF 6-20-89).
9. Effect of reduced Sacramento River flow on the water quality in the west Delta. Consider increasing fresh water flow for improving quality (EDF 6-20-89).
10. Consider use of Delta islands for flood control/bypass water storage, and environmental enhancement purposes (EDF 6-20-89).
11. New levees should be constructed to Division of Safety of Dams specifications. Consider the potential for reduced levee stability resulting from dredging (EDF 6-20-89).
12. Consider global warming, and the potential for sea level rise and changes in runoff patterns (EDF 6-20-89).

The Bay Institute

1. DWR's application should be deferred until the outcome of the Bay-Delta Hearings (TBI 5-23-89).
2. The obvious major purpose of the department's application is to expand diversion methods and opportunities to increase exports of water from the Delta (TBI 5-23-89).
3. The application should be rejected because of the "no net loss of wetlands" policy adopted by EPA (TBI 5-23-89).

Delta Sierra Group

1. The project could and should be designed to enhance wetland habitat. The *hibiscus californicus* is an endangered species in areas of the South Fork Mokelumne River and near Beaver, Hog, and Sycamore Sloughs (DSG 6-12-89).

Table B-3 (Continued)

Operating Engineers Local Union No.3

1. Operating Engineers Local Union No. 3 strongly supports the project (OELU3 6-6-89).

Devils Island, Inc.

1. Opposes dredging and setbacks until DWR the Corps place rip-rap on the exposed sides of the island, agree to deposit dredgings on the island to get the surface above the highest level expected, construct levees, seawalls, and diversion levees to protect the island (DII 6-13-89).

El Camino Boat Club

1. Examine erosion potential of ECBC's island on Little Potato Slough, south of Terminous (ECBC 6-13-89).
2. Evaluate the effect of dredging on crayfish and fish in the area (ECBC 6-13-89).

Phillip Isenberg, Assemblyman 10th District

1. Flood control is a cover for water transfer (PI 6-23-89).
2. Describe benefits to various parties, and the costs to fish and wildlife (PI 6-23-89).
3. Consider alternatives to increased water supply v. water conservation and marketing efforts south of the Delta (PI 6-23-89).

Robert Schaefer

1. Concerned with the subsiding islands on Little Connection Slough, which will be left in a life trust for wildlife and recreation (RS call to S. Buer 5-17-89).

George E. Sims, M.D.

1. Allow the McCormacks to lease their land for flood purposes, growing only summer crops, and selling the stored water in the summer. (GES 6-19-89).

Lloyd B. Ryland

1. Will DWR reimburse property owners at fair market value for property expropriated? (LBR 5-16-89).

Ernest P. Brown

1. A salt water barrier at the mouth of the delta, near Pittsburg is a better solution to the water problems of the Delta (7-24-89).

APPENDIX C

MODELING ASSUMPTIONS AND RESULTS

CONTENTS

CONTENTS (Continued)

Tables

CONTENTS (Continued)

Figures

CONTENTS (Continued)

Figures (Continued)

INTRODUCTION

Model studies performed in support of the North Delta Management Program (NDP) are described in this appendix. Statewide, Delta and North Delta flood models were used as the best available tools to:

- Evaluate the engineering feasibility of proposed alternative North Delta configurations, and
- Assess potential positive and adverse impacts on statewide water and energy supplies and Bay-Delta conditions.

NDP model studies were conducted according to the process and steps depicted in Figure C-1. This modeling process was utilized to perform each model study with the most descriptive and representative assumptions and input data possible. For example, initial DWR/RMA Delta Hydrodynamics Model studies provided information necessary to perform DWRSIM model studies, which in turn provided information necessary to perform DWRDSM model studies. NDP model studies were completed in several steps.

Step 1. Phase I Delta Model Studies

The DWR/RMA Delta Hydrodynamics Model was used to evaluate the hydrodynamic feasibility (channel stage, velocity and flow) of 42 proposed alternative North Delta configurations with several representative low flow summer hydrologies. Model flow results helped to evaluate the relative effectiveness of each alternative configuration in reducing net reverse flows in the lower San Joaquin River and western Delta. Simulated flows for each configuration were also used to determine the water transfer relationship (curve) for the proportion of net Sacramento River flow at Sacramento entering the Mokelumne River system through the Delta Cross Channel and Georgiana Slough.

DWR/RMA Delta Hydrodynamics Model studies provided a basis to select several alternative North Delta configurations for in depth hydrodynamic and salinity evaluation and assessment using the DWR Delta Simulation Model (DWRDSM). These studies also provided the characteristic water transfer relationships for the selected alternative configurations necessary to run the DWR Statewide Simulation Model (DWRSIM).

Step 2. DWRSIM Statewide Operations Model Studies

The DWRSIM model was used to evaluate potential contributions of the NDP to SWP water and energy supply reliability over a 57-year period of historic hydrology, as well as, over an extended historic dry-period, namely, 1928 through 1934. CVP operations were held at current levels during the DWRSIM model runs.

DWRSIM studies were conducted for alternative North Delta configurations selected during Step 1 using the appropriate Sacramento River to Mokelumne River water transfer relationship. The water transfer relationships were used in DWRSIM model studies to estimate the impact of North Delta configurations on net reverse flows in the western Delta, and as a consequence, on additional reservoir releases for carriage water (note: carriage water is additional water released to repel any ocean salinity intrusion resulting from exports from the south Delta). From each DWRSIM study, Delta rim hydrology for the same 16 consecutive water years (1963 through 1978) were selected to conduct Phase II Delta model studies.

Step 3. Phase II Delta Model Studies

The DWR Delta Simulation Model (DWRDSM) was used to help assess the relative hydrodynamic and salinity improvements and impacts of the alternatives selected from Phase I Delta modeling. Each configuration was simulated using hydrologic conditions for 16 consecutive water years generated with the DWRSIM Model. Simulated Delta stages, velocities, flows and salinities were used for the environmental impact assessment.

Step 4. North Delta Flood Modeling Studies

The DWOPER/NETWORK and HEC-1 models were used to evaluate the hydrodynamic feasibility and impacts of proposed alternative North Delta configurations for large flood events. North Delta configurations selected for Phase II Delta Model Studies were evaluated using the 100-year flood events for the Morrison Stream Group, the Cosumnes and Mokelumne Rivers, and Dry Creek. The 1986 flood event was simulated with the DWOPER/NETWORK Model as part of the analysis to verify the model using field data.

Model studies for the NDP are further described in subsequent sections of this appendix, namely, Operation Studies, Delta Modeling Studies, and North Delta Flood Model Studies.

OPERATION STUDIES

Monthly water supply studies of the State Water Project (SWP) and the Central Valley Project (CVP) systems were performed with the Department of Water Resources' statewide simulation model (DWRSIM) to evaluate the impacts of the North Delta Water Management Program (NDP) on the SWP operations. These water supply studies account for the total availability, storage, release, and use of water in the Sacramento and San Joaquin River systems, the Delta, the SWP aqueduct systems south of the Delta, and any proposed additions to the SWP system such as Los Banos Grandes Reservoir (LBG) and Kern Water Bank (KWB). They represent a superposition of future water demands and development on the historical water supply for the 57-year period from water year 1922 through 1978. Such studies provide monthly data on reservoir storage and releases, and Delta inflows, exports, and Delta Outflow Index.

To evaluate the impact of the NDP on Delta inflows, exports, and Delta Outflow Index, three sets of water supply operation studies were simulated assuming SWP projected year 2000 demands of 3.8 million-acre-feet (MAF). The first set (420 series) assumed that four additional pumps at Banks Pumping Plant were operational but without other south Delta improvements, thus limiting SWP allowable diversion capacity to 6,680 cfs (7,300 cfs in some winter months if there is sufficient San Joaquin River flow at Vernalis). The second set (480 series) assumed south Delta facilities such that SWP diversion capacity at the Banks Pumping Plant is 10,300 cfs. The third set (520 series) assumed south Delta facilities, KWB, and LBG are in operation.

A base case and six North Delta alternatives were run for each DWRSIM set of operation studies. DWRSIM studies were conducted for each of the alternative North Delta configurations selected during Phase I Delta model studies using the appropriate Sacramento River to Mokelumne River water transfer relationship. The water transfer relationships were used in DWRSIM model studies to estimate the impact of North Delta configurations on net reverse flows in the western Delta, and as a consequence, on additional reservoir releases for carriage water (note: carriage water is additional water released to repel any ocean salinity intrusion resulting from exports from the south Delta).

Additional DWRSIM runs were made assuming SWP year 2035 projected demands of 4.2 MAF. These studies (530 Series) assumed the same combination of future facilities as the 520 series.

In all studies, SWP facilities were operated in accordance with SWRCB Decision 1485, the Coordinated Operation Agreement, agreements with the Department of Fish and Game, and agreements and contracts with local Delta interests. The operation studies used risk-delivery relationships for SWP deliveries that were designed to simulate the concept and philosophy of criteria adopted by the DWR's Division of Planning in 1990. Table C-1 is a detailed list of assumptions used in the operation studies.

The monthly Delta inflows, exports, and outflows simulated with these operation studies aided in the analysis of possible impacts of the NDP on SWP monthly operational changes, SWP reliability, Delta outflows and outflow pulses, carriage water, striped bass, Chinook salmon, and other fish species, fish food supply, Suisun Marsh, and San Francisco Bay aquatic resources.

Results of these operation studies also provided the hydrologic conditions for the subsequent Delta studies conducted in support of the NDP.

DELTA MODELING STUDIES

Mathematical model studies of flows and salinity in the Sacramento-San Joaquin Delta were conducted in support of the NDP EIR/EIS. These studies were completed in several steps:

- selection and preparation of computer models capable of simulating hydrodynamic and salinity conditions for the Sacramento-San Joaquin Delta based on physical principles and an accurate representation of Delta channel configuration;
- selection of tidal and hydrologic conditions in magnitude and duration appropriate for planning studies;
- preparation of model representation for each proposed facility, channel modification, and export operation;
- Phase I Delta modeling conducted to evaluate the hydrodynamic feasibility of 42 proposed alternative NDP configurations;
- selection of several alternative North Delta channel configurations for more detailed hydrodynamic and salinity modeling to assess their environmental impacts; and
- Phase II hydrodynamic and salinity modeling conducted to assess the relative improvements and impact of the alternatives selected after Phase I modeling, as compared to projected no-action conditions, over a wide range of hydrologic conditions.

Delta Mathematical Models Used

Two computer simulation models of the Sacramento-San Joaquin Delta were used for evaluating the hydrodynamic and salinity responses of various alternative configurations. These models and important attributes are now described.

DWR/RMA Delta Hydrodynamics Model (1989 verified version). The DWR/RMA Delta Hydrodynamics Model was selected to simulate water surface elevations and flow/velocity patterns in the Delta. The Delta is characterized by the model as being bounded by the communities of Sacramento on the north, Vernalis on the south, and Martinez on the west. A schematic representation of the Delta used for this model is shown in Figure C-2. The following attributes of this model are of particular importance:

- the most up-to-date descriptions of Delta channel bathymetry are used;
- timed operations of forebay intake gates such as the SWP Clifton Court Forebay can be simulated;
- existing and proposed hydraulic structures such as the Delta Cross Channel, intake culverts to Tom Paine Slough, and Suisun Marsh Salinity Control Gates can be simulated;

- the most up-to-date descriptions of diversion and drainage return flows in the Delta both in magnitude and spatial distribution are used.

In 1987, the DWR Delta Modeling Section calibrated the DWR/RMA Delta Hydrodynamics Model using recorded 15-minute stage data from thirty-nine monitoring stations for July 1 through 4, 1979. The model was verified using data for July 5 through 30, 1979. The model was verified in 1989 for high flows using recorded 15-minute stage data from twenty-three monitoring stations for February 1 through 28, 1986. Most recently, this model was verified for May 1 through 31, 1988, using recorded 15-minute stage data from twenty-seven monitoring stations, as well as, stage, flow and velocity data from eighteen monitoring sites for selected days in May 1988.

DWR Delta Simulation Model (1989 verified version; developed from the Fischer Delta Model, Version 7E). The DWR Delta Simulation Model (DWRDSM) was selected to simulate dissolved salt transport and hydrodynamics in the Delta for a 16-year period (simulation water years 1963-1978). A schematic representation of the Delta used for this model is shown in Figure C-3. The following attributes of this model are noteworthy:

- a Lagrangian solution method for dissolved salt transport is used which substantially reduces numerical dispersion common to Eulerian solution methods;
- timed operations of forebay intake gates such as the SWP Clifton Court Forebay can be simulated;
- it simulates existing and proposed hydraulic structures such as the Delta Cross Channel, intake culverts to Tom Paine Slough, and the Suisun Marsh Salinity Control Gates. All gate operation timing can be specified and gradual gate opening and closing is used;
- the most up-to-date descriptions of diversion and drainage return flows in the Delta both in magnitude and spatial distribution are used.
- it simulates dissolved salt transport (total dissolved solids, TDS) in the Delta for numerous consecutive years on a 10-minute time interval.

In 1989, the DWR Delta Modeling Section calibrated and verified the hydrodynamic module, DWRDSM/Hydro using recorded 15-minute stage data from twenty-seven monitoring stations for May 1 through 31, 1988, as well as, stage, flow and velocity data from eighteen monitoring sites for selected days in May 1988. In 1990, DWRDSM/Hydro was also verified against 15-minute stage data for the Delta and Suisun Marsh for December 1988, February 1989, April 1989 and December 1989. In 1989, DWR calibrated the salinity transport module, DWRDSM/Qual using the 19-year mean, 25-hour tide at Martinez and hydrology and salinity data for the entire year of 1968. DWRDSM/Qual was calibrated using mean tidal day salinity data (electrical conductivity converted to total dissolved solids) from sixteen monitoring sites for 1968.

Phase I Delta Modeling

Phase I modeling evaluated the feasibility of various combinations of North Delta channel configurations under a representative range of summer hydrodynamic conditions. This was accomplished by simulating Delta flows, velocities, and water levels under extreme summer hydrologic conditions with the DWR/RMA Delta Hydrodynamics Model. This process consisted of: 1) selecting and preparing an appropriate tide, Delta channel diversion and drainage return data, and hydrologic conditions, 2) defining a large number of alternative North Delta configurations and envelope of hydrologies, 3) evaluating the alternatives with the DWR/RMA Delta Hydrodynamics Model using six different hydrologies, 4) defining and evaluating additional alternatives with a single representative hydrology and, 5) final evaluation and selection to determine alternatives for Phase II Delta model studies.

The DWR/RMA Delta Hydrodynamics Model was run for one tidal cycle with the 19-year mean, 25-hour tide for Martinez. This was considered reasonable for the evaluation and comparison of various alternative configurations based on average water level, net flow and net velocity patterns in the Delta. It was also considered reasonable for the evaluation of general trends in instantaneous 15-minute water levels, flows and velocities and determining the net water transfer from the Sacramento River to the Mokelumne River system through the Delta Cross Channel and Georgiana Slough.

Assumptions and Input. The boundary tide at Martinez/Benicia in Carquinez Strait was selected to represent an average tidal pattern. Delta consumptive use patterns and boundary Delta hydrologic conditions were selected to collectively provide a representative critical summer condition. It is anticipated that performance of alternative North Delta configurations would frequently be better than those studied in the Phase I modeling. Improvements to Delta water conditions were assessed by examining reductions to net reverse flow in the lower San Joaquin River with and without 10,300 cfs SWP export pumping capacity and by checking flow patterns in North Delta channels. Modeling results incorporating North Delta alternatives are assumed to exhibit a comparable incremental impact on Delta hydrodynamics as would be observed in the field.

a. *Boundary Tide.* The 19-year mean, 25-hour Martinez tide is imposed at the boundary to drive the system hydrodynamics. This tide is presented in Figure C-4.

b. Delta Consumptive Use. For Delta modeling, Delta channel diversions and drainage return flows were estimated by DWR with a consumptive use analysis of 142 areas in the Delta and a survey of current diversion siphons and drainage pipes. Constant rates for channel diversions and drainage returns over one tidal cycle (25 hours) were used for the DWR/RMA Delta Hydrodynamics Model. Delta-wide channel diversions, drainage returns and net channel depletion are presented in Table C-2.

c. Boundary Hydrologic Conditions. Six different Delta hydrologic conditions were used in Phase I modeling to characterize three SWP export levels and four different Sacramento River flows. The six Delta rim hydrologies used in Phase I Delta modeling are reported in Table C-2 as hydrology sets 1 through 6. The first three hydrologies represent a Net Delta Outflow Index of 2500 cfs as mandated by Decision 1485, while the other three cover a wide range of SWP export pumping with Sacramento River flow remaining constant.

d. SWP Forebay Gate Operation. The Victoria-Byron-Clifton Court Forebay alternative from the South Delta Water Management Program with intake gates on Middle River at Woodward Canal was used in all Phase I Delta model studies. This was necessary to enable SWP exports of 10,300 cfs. The operation of SWP forebay intake gates for Phase I is shown at the top of Table C-3. This operation was designed to 1) take water into the SWP forebay through the peak of the high-high tide and through the low-high tide and 2) discontinue forebay inflow during the low-low tide and high-low tide. The tide at the forebay intake gate location was simulated with the DWR/RMA Delta Hydrodynamics Model without SWP exports. The resulting tide stages at the Middle River forebay intake gate location is presented in the center panel of Table C-3. Forebay gate operations were then determined by using the Phase I gate operation in conjunction with the simulated tide for Middle River at Woodward Canal. The resulting gate operations are presented at the bottom of Table C-3.

e. North Delta Configurations. Alternative North Delta configurations evaluated in Phase I modeling were comprised of different combinations of existing and proposed channel configurations and Delta Cross Channel gate dimensions. These alternative configurations were generated with different combinations of the following components:

- Enlarging portions of the south and north forks of the Mokelumne River, Georgiana Slough, Snodgrass Slough, Dead Horse Cut, Little Potato Slough, and Little Connection Slough. Channel enlargement consisted of dredging and in some cases levee setback;
- Increasing Delta Cross Channel flow capacity; and
- Using Staten Island and small portions of Bouldin and Andrus Islands as a floodway.

All components that were considered are shown in Table C-4. Each component is defined and given an identification number in Table C-4, and Phase I Delta modeling alternative configurations are reported in Table C-5. The South Delta configuration described in the previous section was kept the same for all North Delta configurations.

The first 21 alternative configurations listed in Table C-5 were defined by combining various components listed in Table C-4. Every combination was simulated with the six different hydrologies presented in Table C-2 to evaluate how each alternative impacted the Delta under various hydrodynamic conditions. After the first 21 alternative configurations were completed, changes in North Delta flow patterns for each hydrology became more predictable. Therefore, configurations 22 through 42 were only simulated using hydrology set 2, a typical summer hydrology. Configurations 22 through 42 were simulated to address specific questions about additional components and the sensitivity of previous ones to the additional components. Differences in results between runs were analyzed.

All model results were evaluated in relation to the No-action (base case) configuration, configuration 1 in Table C-5. The base case configuration includes the following components:

- Existing North Delta configuration
- Victoria-Byron-Clifton Court Forebay
- SWP Forebay intake on Middle River at Woodward Canal
- Tidal barriers in the south Delta in Middle River, Old River and Grant Line Canal
- Delta Cross Channel gates open
- Suisun Marsh Salinity Control Gates operating

Phase I Modeling Results. DWR/RMA Delta Hydrodynamics Model simulations were conducted with the tide and hydrology data mentioned above, for each North Delta configuration displayed in Table C-5. Model results include minimum, mean and maximum tidal cycle water surface elevations; minimum, maximum and net tidal cycle velocities and flows; and 15-minute velocities and flows over the 25-hour simulation period.

Model results for configurations 1 through 21 for six different hydrologies were presented graphically to expedite the comparative evaluation of many simulations. For these configurations, the following graphical displays were generated and analyzed:

1. Average Tidal Cycle Flows in the Delta,
2. Average Tidal Cycle Flows in the North Delta,
3. Average Tidal Cycle Velocities in the North Delta,
4. Maximum Tidal Cycle Velocities in the North Delta,
5. Minimum Tidal Cycle Stages in the North Delta,
6. Flow Profiles at Key Delta Locations
7. Velocity Profiles at Key Delta Locations

Sample model results are presented in Figures C-5 through C-7 for the base case configuration (Table C-5) with hydrology set 2 (Table C-2). Items 1 and 5 are displayed in Figure C-5, items 2 and 6 are displayed in Figure C-6, and items 3, 4 and 7 are displayed in Figure C-7. The twelve locations presented in items 6 and 7 are important locations with respect to alternative North Delta configurations. The DWR/RMA Delta

Hydrodynamics Model channel numbers are listed in Figures C-6 and C-7 (e.g., C-139) for the flow and velocity reporting locations (see Figure C-2 for model grid map).

Model results for configurations 22 through 42 were analyzed using stage, flow and velocity data for a number of channels at key locations. in the North and West Delta. These configurations were run with hydrology set 2.

Selection Of Phase II Alternative Configurations

For Phase II Delta modeling, three alternative North Delta configurations were selected from the 41 alternatives evaluated in Phase I Delta modeling. These alternatives were selected based on a combined assessment of stage, flow and velocity improvements for flood and low flow conditions, and a cost analysis. In addition, each of the three selected alternatives were evaluated once with the existing SWP Clifton Court Forebay and once with the enlarged SWP forebay, namely, the Victoria-Byron-Clifton Court Forebay. These six alternatives, and the configuration representing existing Delta conditions (designated as the no-action alternative) are summarized in Table C-6.

It should be noted that the configuration identification numbers reported in Table C-6 are not the same as the alternative identification numbers reported in Tables C-7 through C-11. A cross reference is reported in Table C-6 in the column labeled ALT.

Phase II Delta Modeling

Phase II modeling generated the information to assist the evaluation of environmental impacts of alternative combinations of North Delta facilities. This was accomplished by 1) selecting an appropriate time period that has a range of hydrologic conditions, 2) evaluating the mean monthly hydrodynamic responses of the no-action and six alternative configurations reported in Table C-6 with DWRDSM/Hydro, and 3) evaluating the mean tidal daily salinity responses of the alternatives with DWRDSM/Qual.

Assumptions and Input. The following is a description of the assumptions and input used in the modeling runs:

a. Boundary Tide. The 19-year mean, 25-hour Martinez tide was used for the boundary tide.

b. Boundary Salinity. DWRDSM/Qual is driven by a specified salinity boundary condition for Martinez. The simulation model SALDIF4 was used to generate the boundary salinity data in the form of daily average salinities (TDS) at Martinez. SALDIF4 requires net Delta outflow as input. Net Delta outflow data was extracted from the DWRSIM base condition study (2000-BASE-423D). Program SALDIF4 was executed sequentially for the 57 years of monthly net Delta outflow data available from DWRSIM to produce a 57 year record of tidal daily average salinity at Martinez. This data set was used for boundary salinity in each of the seven runs.

c. Delta Consumptive Use. For Delta modeling, Delta channel diversions and drainage return flows were estimated by DWR with a consumptive use analysis of 142 areas in the Delta and a survey of current diversion siphons and drainage pipes. Constant rates for channel diversions and drainage returns over one tidal cycle (25 hours) were used for DWRDSM/Hydro to represent monthly average conditions .The monthly diversions and returns from the consumptive use analysis were adjusted to obtain the same net Delta channel depletions used in DWRSIM operations studies. Concentrations of the drainage water were assigned based on field data reported in DWR Bulletin 123.

d. Boundary Hydrologic Conditions. Delta hydrology data were provided by DWRSIM studies discussed in the Operation Studies section. These studies provided monthly average Delta inflows, exports, and net Delta outflow index over a 57-year study period reflecting the components in the NDP with and without alternative South Delta facilities. For Phase II modeling, Delta boundary hydrology was changed once per month for 16 consecutive years to evaluate and compare the impact of various alternative configurations on monthly average salinity throughout the Delta. The 16 year period was selected to include all water year types, wet, above normal, below normal, dry, and critical.

e. SWP Forebay Gate Operation. The SWP Forebay was operated with a hydraulic gradient criteria. Flow is allowed into the forebay when the water surface elevation outside the forebay is greater than the water surface elevation inside. When the water surface gradient is reversed, the forebay intake is closed. This gate operation was designed to take water into the SWP forebay whenever possible. Tide barriers were placed in south Delta channels near the forebay intake when the enlarged forebay and 10,300 cfs export capacity were simulated. Each of the three North Delta configurations were simulated with both the existing Clifton Court Forebay and the Victoria-Byron-Clifton Court Forebay. The existing forebay is 2100 surface acres and the maximum inflow is constrained to 15,000 cfs. The enlarged forebay is 5000 surface acres and the maximum intake rate is 30,000 cfs.

f. Channel Modifications. Channel geometry in the DWRDSM model was modified, when necessary, to simulate the NDP configurations reported in Table C-6.

g. Delta Cross Channel Gate Operation. Decision 1485 requires that the Delta Cross Channel be closed between January 1 and April 15 if the daily Delta Outflow Index (DOI) is greater than 12,000 cfs. Between April 16 and May 31, the Delta Cross Channel gates are required to be closed if the DOI is greater than 12,000 cfs, but for no more than two consecutive days in four, and no more than 20 days total. Since DWRSIM generates monthly average hydrology data, DWRDSM simulations were made with the Delta Cross Channel gates closed when the DOI from DWRSIM was greater than 12,000 cfs between January 1 and April 31.

h. Alternative North Delta Configurations. The no-action and six alternative configurations selected for Phase II modeling are defined in Table C-6 and depicted in Figure C-8. Each of the three alternative North Delta configurations were simulated with two south Delta configurations, namely, the existing Clifton Court Forebay and the enlarged Victoria-Byron-Clifton Court Forebay with intake on Middle River at Woodward Canal. Alternative North Delta configurations include a combination of dredging and levee setback in North Fork Mokelumne River, South Fork Mokelumne River, Snodgrass Slough and Dead Horse Cut, and enlargement of Delta Cross Channel gates. Included with the Victoria-Byron-Clifton Court Forebay are enlarged forebay intake gates, tide barriers in Middle River, Old River and Grant Line Canal, and dredging in Middle River near the enlarged forebay intake.

The no-action (base case) and six alternative configurations presented in Table C-6 were evaluated with both the hydrodynamic and salinity modules of DWRDSM. These simulations were made with the tide, channel depletion and hydrology data described above to represent mean monthly hydrodynamic conditions for water years 1963 through 1978.

Phase II Modeling Results. Phase II modeling provided monthly average water levels, and net velocities and flows, as well as, monthly average, minimum and maximum surface zone salinity as total dissolved solids (TDS) throughout the Delta. The analyses for environmental impacts of North Delta configurations were based on the monthly averages for daily maximum, minimum, and average water levels, net flows and net velocities, as well as, monthly average TDS throughout the Delta.

Three of the seven North Delta configurations evaluated in Phase II Delta modeling were included in the final eleven alternative North Delta configurations evaluated in Chapter 5 (Environmental Impacts). Configurations 1, 2 and 4 in Table C-6, are Alternatives 1, 2A, and 3B, respectively, of the final eleven alternatives. Model studies were not performed during Phase II Delta modeling for the remaining eight alternatives evaluated in

Chapter 5. The Reverse Flow Index was developed and used to estimate the hydrodynamic and salinity impacts for the remaining eight alternatives.

The Reverse Flow Index is the net tidal cycle reverse flow in the western Delta as defined in Chapter 5, Reverse Flow Section. The Reverse Flow Index was determined for each North Delta configuration evaluated in Phase I Delta modeling (Table C-5) using the DWR/RMA Delta Hydrodynamics Model with hydrology set 2 (Table C-2). Reverse Flow Index was related to the channel cross sectional area of the South Fork Mokelumne River for various configurations. One curve was constructed for each Delta Cross Channel gate size to develop a family of curves. Reverse Flow Index was also related to other environmental parameters to evaluate the overall validity of the Index. These parameters include Sacramento River to Mokelumne River water transfer ratio, net Delta Outflow Index, and TDS.

The constructed curves were used to estimate net reverse flow and TDS for North Delta configurations not yet modeled based on the desired channel cross sectional area modification and Delta Cross Channel gate size.

a. Sample Graphical Display. Model results were presented graphically on Delta schematic maps to show mean monthly salinity conditions for each alternative for comparative evaluations. An example schematic map with contours of monthly average total dissolved solids in the Delta is shown in Figure C-9.

b. Summary Tables. Tables C-7, C-8, C-9, C-10, C-10A and C-10B contain simulated monthly average salinity at Decision 1485 standards locations. The information shown in these tables should only be used to compare the various alternatives in the NDP based on the relative changes in TDS from the no-action alternative (Alternative 1). Reported salinity values are provided to indicate the general range of changes in Delta TDS for the alternatives under a wide range of hydrologic conditions. Absolute TDS values for the interior Delta are not reported because DWRDSM salinity results for this region can be significantly affected by the drainage return qualities which were specified as inputs to the model.

Simulated monthly average net flows for Sacramento River, Georgiana Slough and the Delta Cross Channel are reported in Table C-11 for the final eleven alternative North Delta configurations for five water year types. The water transfer ratio (transfer coefficient) is defined as the sum of net Delta Cross Channel and Georgiana Slough flows divided by Sacramento River flow near Sacramento. The water transfer ratio was determined for each alternative on a monthly basis and are reported in Table C-11.

The water transfer ratio is an indication of the capacity of the Delta Cross Channel and Georgiana Slough to divert water from the Sacramento River to the Mokelumne River system, and to reduce net reverse flow in the western Delta. Higher ratios indicate larger water diversions into the Mokelumne River system and reductions in net reverse flows.

Flows reported in Table C-11 are from Phase II Delta model studies using DWRDSM for alternatives 1, 2A and 3B, and estimates using the Reverse Flow Index for the other eight alternatives. The ratios are for hydrodynamic conditions simulated with the existing South Delta configuration, and for hydrologic conditions simulated with DWRSIM assuming existing water storage facilities south of the Delta.

NORTH DELTA FLOOD MODELING STUDIES

The purpose of this study was to analyze the impact of a 100-year flood event on the northern Delta area. This was done in the following stages:

1. Used DWR/RMA Delta Hydrodynamics Model to establish initial conditions.
2. Developed mathematical relationship to represent Lambert Road hydraulic structure.
3. Simulated 1986 Flood to verify the model. Compared the results of model against field data. Levee break analysis was part of this simulation.
4. Developed the 100-year flood hydrographs for the rim flows at Morrison Creek, Dry Creek, Mokelumne, and Cosumnes Rivers.
5. Used the 100-year flood stage at Georgiana Slough as the downstream boundary condition.
6. Based on the current channel geometry, and configuration, made the model runs and analyzed the results.
7. Tested different channel geometry alternatives, including various combinations of dredging and levee set backs, with and without the proposed Lambert Road Structure, with a range of levee break scenarios, and using both the February 1986 flood hydrology and the 100-year flood hydrology.

Geographical Extent

The area under investigation (Figure C-10) starts upstream of Morrison Creek near Freeport in the north, southern end of the North Fork and the South Fork of the Mokelumne in the south, western levees along Snodgrass Slough and the North Fork of Mokelumne in the west, and Ray Road and upstream portions of the Cosumnes and Mokelumne Rivers in the east. The NETWORK model schematics for area under investigation is illustrated in Figure C-11.

Mathematical Models Used in the Analysis

DWOPER Model. The DWOPER model is a dynamic wave operational model developed by NWS Hydrologic Research Laboratory in the early 1970s. This dynamic wave routing model is based on an implicit finite difference solution of the complete one-dimensional St. Venant equations of unsteady flow. The model is implemented where backwater effects and mild bottom slopes are most troublesome for hydrologic routing methods. It is in operational service or in the process of being implemented on the Mississippi, Ohio, Columbia, Missouri, Arkansas, and some other rivers in the country.

DWOPER features the ability to use large time steps for slowly varying floods and to use cross-sections spaced at irregular intervals along the river system. The model is generalized for wide applicability to rivers of varying physical features, such as irregular geometry, variable roughness parameters, lateral inflows, flow diversions, off channel storage, local head losses such as bridge contraction-expansions and weir or culvert flow, lock and dam operations, and wind effects.

The Corps has used an earlier version of the model in the past to analyze flooding in the area under investigation. The limitation with this earlier model was that it could not model the complex branching and interconnections of the North Delta channels.

NETWORK Model. The NETWORK model is a generalized dynamic wave model for one-dimensional unsteady flows in a single or branched waterway. It contains all of the capabilities available in DWOPER plus the ability to handle the sparse matrix of equations resulting from the analysis of branched estuaries. The Lambert Road Structure (Figure C-12) containing culverts, flap gates, and weir flow capability is mathematically simulated (Figure C-13).

The NETWORK model is being used to analyze the impact of a 100 year flood event in the North Delta area. A grid, illustrated in Figure (C-11), containing the important channels which convey water in the event of a 100 year flood was prepared. This grid has 118 cross-sections, 35 off channel storage areas, 19 lateral inflow and outflow locations, and 6 junctions.

The NETWORK model has been applied to simulate the February 1986 flood event in the North Delta. The model results agree with the historic data fairly well. The levee breaks around McCormack Williamson Tract, Glanville Tract, Dead Horse Island, New Hope Tract, and Tyler Island during the 1986 Flood have been included in the NETWORK model simulations. The observed tidal stage data at Georgiana Slough near the junction of the North Fork and South Fork Mokelumne was used as the downstream boundary condition.

To simulate the 100-year flood event, it was assumed that only McCormack Williamson Tract and Glanville Tract levees were breached when the stage at these locations reached elevation 13 feet NGVD. The 100-year flood stage of 7.7' NGVD was used at the lower boundary and it was kept constant throughout the simulations to prevent tidal fluctuations from distorting the alternative analysis. Channel modifications alter the timing as well as magnitude of the flood peak. If the peak of the flood wave coincides with high tide the resultant stage could be significantly greater than if it coincides with a lower tide.

Geometry and Manning's 'n' Values

There were a number of steps in determining and compiling the geometry and the Manning's 'n' values used in the NETWORK model. First, the necessary cross-sections were identified. Second, sources for cross-section data were identified. Third, Manning's 'n', storage areas, and channel lengths between the cross-sections were described. Finally, all of the components were entered into a program GEDA, which converts HEC-2 input data to DWOPER/NETWORK input. The following is a more detailed discussion of the process.

Topographic maps were used to determine cross-section location and boundaries. All necessary cross-sections were drawn on the maps. Cross-sections were selected and spaced along the channels to adequately describe transitions, structures, storage areas, and gradual variations in channel geometry as required by the model.

Data for the cross-sections came from topographic maps, Delta modeling data, and field surveys. Around the northern Morrison Creek area and the eastern Mokelumne River/Cosumnes River area, topographic map data was used to develop cross-sections. Field surveys covered the areas south of Lambert Road on Snodgrass Slough, Dead Horse Cut, Mokelumne River west of Interstate-5 to New Hope Landing, Lost Slough, Beaver Slough, Hog Slough, and Sycamore Slough. Delta modeling data covered the North and South Fork Mokelumne Rivers. Benchmarks used in the survey were identified to facilitate future surveys and accuracy checks.

For each cross-section and channel length Manning's 'n', storage, and length were described. Manning's 'n' for each cross-section was determined through pictures, field inspection, and engineering judgment. The 'n' values were chosen to coincide with winter-spring conditions. Flow lines were drawn between cross-sections to determine active and inactive areas as well as curvature between cross-sections. Channel segment lengths were measured from topographic maps.

Simulation of the 1986 Flood

A period of eight days starting at one o'clock in the morning on February 14,1986 and ending at mid-night on February 21,1986, during the 1986-Flood, was chosen for the NETWORK model simulation purpose. The input hydrographs at the junction of Mokelumne River and Dry Creek and at Cosumnes River were developed by using combination of historic data, HEC-1 model, and river routing (Figure C-14). The Morrison stream group input hydrographs are illustrated in Figure C-15 and the combined inflow hydrograph is shown in Figure C-16.

The actual levee break hydrographs for the simulation period at McCormack Williamson Tract, Glanville Tract, Dead Horse Island, Tyler Island, and New Hope Tract are illustrated in Figure C-17.

The recorded historic tide at Georgiana Slough for the period of the eight days was used as the downstream boundary tide (Figure C-18).

Stage and Flow at Lambert Road Structure. For the 1986 flood, actual levee breaks, no-action alternative, and current Lambert Road Structure scenario the stage and flow plots are presented in Figure C-19. These represent the stages and flows at cross section no. 77, just upstream of the structure, and cross section no. 78, located at downstream of Lambert Rd. The elevation at top of the bridge deck is 11 feet,NGVD. The Lambert Road Structure has flap gates at the downstream end. These flap gates do not allow water to flow upstream as long as the stage stays below the top of bridge deck elevation, 11 feet,NGVD. Flow reversal occurred when the stage at downstream became higher than 11 feet. This period is indicated by the negative value for the flow in the flow plot at the bottom. The period of no flow (flow=0.0) represents the condition when the stage at downstream was higher than upstream but less than 11 feet, NGVD.

Water Surface Profiles. In order to plot the water surface profiles along different channels in the study area, two profile alignments were chosen (Figure C-20). Profile A covered the channels starting at section no. 54, starting point along the Morrison Stream Group, Snodgrass Slough, and the North Fork of Mokelumne. Profile B contained the channels starting at section no. 6, junction of Mokelumne and Dry Creek, Mokelumne River, and the South Fork of Mokelumne.

The water surface profiles at four different times were plotted in Figure C-21. These included the water surface profile at 4 PM on February 15 (that was during low flow period), the water surface profile at 2 PM on February 18 (just prior to flooding) , at 6 AM on February 20 (just about flood peak) , and at 2 AM on February 21 (immediately after the flooding peaked).

Flow Schematics Along Different Channels. The magnitude and direction of the flow at different channels and during the four different times (same as those picked for the Water Surface Profile study) is illustrated in Figures C-22 through C-25. The bold numbers next to the arrows indicate the magnitude and the numbers inside the arrows represent the channel cross sections.

Model Verification. The NETWORK model used in this study was not calibrated under a specific hydrologic condition. However, the Manning's "n" values used in the simulation were carefully determined by field inspections and engineering judgments. The channel cross sections were determined very carefully also. Then the model was applied directly to simulate the 1986 Flood without making any adjustments to Manning's "n" values. Therefore, this was considered as the verification run. Three locations where the stage was recorded for the whole simulation period were chosen for the verification purpose. These stage stations were: The Delta Cross Channel, Benson's Ferry, and New Hope Landing. The result of the model run and the recorded historic stage data are plotted in Figures C-26 through C-28. Figure C-28 indicates that the stage recorder at New Hope Landing was out of order during February 18 and part of February 19.

Comparison of the Impact of Different Alternatives. During this investigation, many different alternative scenarios were studied. However, only the impact of the preferred alternative and the proposed Lambert Road Structure are presented here. For the actual levee breaks as they occurred during the 1986-Flood and current channel configurations, the no-action alternative, the impact of the proposed Lambert Road Structure is illustrated in Fig. C-29. To study the impact of the preferred alternative plan, the 1986-Flood hydrology was used with the assumption that only McCormack Williamson Tract and Glanville Tract would be flooded when the stage at Mokelumne River around McCormack Williamson Tract reached elevation 13 feet, NGVD. The impact of the preferred alternative with the current Lambert Road Structure is illustrated in Figure C-30. The same model run was repeated with the assumption the the proposed Lambert Road Structure would be in place and the result is indicated in Figure C-31.

Simulation of the 100-Year Flood

To simulate the 100-Year flood event in the North Delta study area, it was assumed that the most critical case would be the one if a 100-Year storm occurred over Cosumnes River Basin. Based on this assumption the 100-Year flood inflow hydrographs for Cosumnes and Mokelumne Rivers and Dry Creek were developed (Figure C-32). A simulation duration period of eight days was chosen for the analysis purpose. The 100-Year inflow hydrographs for the Morrison Stream Group, with the assumption of the 100-Year storm centering over Cosumnes River, were computed from the local rainfall data by using the HEC-1 model. The current level of development at Morrison Creek Basin was considered for this analysis (Figure C-33). The combined 100-Year hydrograph for the Morrison Stream Group is plotted in Figure C-34).

Different level of development at Morrison Creek Basin and the centering of the 100-Year storm over different location in the North Delta study area would produce considerably different inflow hydrograph for the Morrison Stream Group. The following inflow hydrographs were computed by HEC-1 but were not used for the flood analysis. These are illustrated in Figures C-35 through C-38.

The levee break hydrographs for the 100-Year flood analysis are plotted in Figure C-39. It was assumed that when the stage at the Mokelumne River channels around McCormack Williamson Tract reached elevation 13 feet, NGVD, then these levees and Glanville Tract would be breached. The levee breach hydrographs are shown in Figure C-39.

The 100-year flood was simulated by assuming the 100-Year flood stage of 7.7 feet, NGVD at Georgiana Slough as the downstream boundary condition. The stage was kept constant throughout the simulation.

Some of the results of the model runs for the 100-Year flood analysis in the North Delta area, produced by the 100-Year storm over Cosumnes River Basin and considering current level of development in the Morrison Creek Basin are presented in the following.

Water Surface Profiles. The water surface profiles for four different scenarios are plotted in Figure C-40. For the 100-Year storm centering over Cosumnes River Basin and the current level of development at Morrison Creek Basin, the four scenarios were:

1. No-Action Alternative/ Current Lambert Rd Structure,
2. Preferred Alternative/ Current Lambert Rd Structure,
3. No-Action Alternative/ Proposed Lambert Rd Structure, and
4. Preferred Alternative/ Proposed Lambert Rd Structure.

Velocity Profiles. In order to study the impact of the preferred alternative plan on the channel velocities, plots of the velocity profiles at different locations were made (Figure C-41). These plots include the velocity profiles for the no-action alternative for comparison purpose. For both conditions, it was assumed that the levees around McCormack Williamson Tract and Glanville Tract would be breached when stage at these locations reached 13 feet,NGVD, the 100-Year storm centered over Cosumnes River Basin, with current level of development at Morrison Creek Basin, and with current Lambert Road Structure.

Summary

The peak stages at various locations with in the study area for different scenarios are tabulated in Tables C-12 and C-13. Table C-12 contains the recorded February 1986 peak stages at different stations and the peak stages for six different model runs for the 1986 Flood simulation considering various scenarios. The 100-Year peak stages, computed by the NETWORK model, based on different set of assumptions are tabulated in Table C-13. These assumptions are listed as the headings at top of the table. Summary of the flood statistics for both the February 1986 and the 100-Year Flood events are illustrated in Table C-14.

TABLE C-1
BASIC ASSUMPTIONS AND OPERATION CRITERIA IN STATEWIDE OPERATION STUDIES IN SUPPORT OF NORTH DELTA WATER MANAGEMENT PROGRAM

1. 420 Series

A. No-Action Study (423 D)

- 2000 level hydrology and upstream depletion, based on DWR Bulletin 160-74 projections (57 years: 1922-1978).
- No North Delta or South Delta Improvements.
- Sherman Island Overland Facility in operation, thus satisfying the water quality requirements specified in the DWR contract with the North Delta Water Agency.
- Minimum Delta outflow requirements maintained to satisfy D-1485, assuming the Interim Suisun Marsh Criteria.
- Carriage water requirements based on the allowable export / salinity repulsion curves for Rock Slough, designed to maintain a water quality of 130 ppm during winter and spring months and 225 ppm during summer and fall months.
- SWP Banks Pumping Plant capacity with 4 new pumps is set at 6,680 cfs (or 7,300 cfs in some winter months) in accordance with the USCE operating permit criteria. Pumping is limited to 3,000 cfs in May and June, and 4,600 cfs in July to comply with D-1485 criteria for striped bass survival. Additionally SWP pump ing is limited to 2,000 cfs in any May or June in which storage withdrawals from Oroville Reservoir are required for export (per the January 5, 1987 Interim Agreement between DWR and the California Department of Fish and Game).
- CVP Tracy Pumping Plant capacity is 4,600 cfs, but constraints along the Delta Mendota Canal and at the relift pumps (to O'Neil Forebay) restrict capacity to 4,200 cfs at that point. Pumping also limited to 3,000 cfs in May and June in accordance with D-1485 criteria.
- Wheeling of CVP water through SWP facilities to San Luis Reservoir only when unused SWP Banks Pumping Plant capacity is available. Annually, the amount of CVP water wheeled is limited to what is needed to offset the CVP Tracy Pumping Plant's compliance with D-1485 criteria.
- CVP/SWP sharing of responsibility for the coordinated operation of the two projects maintained per the Coordinated Operation Agreement; with storage withdrawals for in-basin use split 75 percent CVP/ 25 percent SWP, and unstored flow for storage and export split 55 percent CVP/ 45 percent SWP.
- San Luis Joint Reach canal (check 12) enlarged by 1,000 cfs, to a capacity of 8,100 cfs at its smallest reach.
- East Branch of the California Aqueduct is enlarged by 1,500 cfs, to a final capacity of 3,149 cfs, downstream of Alamo Power Plant, and 2,811 cfs at Devil Canyon Power Plant. The Santa Ana Pipeline to Lake Perris has been enlarged to 730 cfs capacity to supply the demands of Reaches 28G through 28J.
- Trinity river minimum fish flows maintained at 340, 220 or 140 TAF/year using the Shasta criteria, per recent agreement between the USBR and the U.S. Fish and Wildlife Service.
- Sacramento River fishery flows below Keswick Dam maintained per the agreement between U. S. Bureau of Reclamation and California Department of Fish & Game (revised October 8) ranging from 2600 to 3900 cfs depending on the time of year.
- Sacramento River navigation control point (NCP) flows maintained at 4,000 cfs (April -October) or 3,000 cfs (November - March) at Wilkins Slough, in accordance with the original legislation that authorized the CVP in 1935 and 1937. Flows would be reduced in critical water years.
- Feather River fishery flows maintained per the agreement between DWR and the California Department of

TABLE C-1 (Continued)

BASIC ASSUMPTIONS AND OPERATION CRITERIA IN STATEWIDE OPERATION STUDIES IN SUPPORT OF NORTH DELTA WATER MANAGEMENT PROGRAM

A. No-Action Study (423 D) (Continued)

Fish & Game (August 26, 1983). In normal years these minimum flows are 1700 cfs from October through March and 1000 cfs from April through September, with lower minimum flows allowed in dry/critical water years.

- Oroville flood control storage based on the 1989 USCE revised diagram.
- American River minimum fish and recreation flows based on the storage in Folsom Lake per USBR operation criteria, as follows:

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
CFS MIN	2000	1500	1500	1500	1500	1500	1500	2000	2000	2000	2000	2000
W/STO >	600	600	600	650	710	760	850	900	800	800	700	650
CFS MIN	1375	1250	1250	1250	1250	1250	1250	1375	1500	1500	1500	1500
W/STO >	400	400	400	400	550	600	650	750	700	610	500	400
CFS MIN	1000	1000	1000	1000	1000	1000	1000	1375	1500	1500	1500	1250
W/STO >	300	250	250	350	520	570	600	570	500	400	350	300
CFS MIN	500	500	500	500	500	500	500	500	500	500	500	500
W/STO >	200	200	100	220	300	380	400	350	300	300	250	200
CFS MIN	500	500	500	250	250	250	250	250	250	250	250	375
W/STO	90	90	90	90	90	90	90	90	90	90	90	90

- Stanislaus River minimum fish flows below New Melones Reservoir are set at 98 TAF/year per earlier agreements between California Department of Fish & Game and U. S. Bureau of Reclamation.
- San Joaquin River water quality standards at Vernalis are maintained per SWRCB Decision 1422 by making New Melones Reservoir releases when necessary. An older flow/salinity relationship developed in 1982 was used to calculate the amount of New Melones releases necessary to blend with the San Joaquin River water to maintain the 500 ppm TDS standard.

- 2000 level CVP demands as follows:

Contra Costa Canal	**	160 TAF/Year
DMC and Exchange	**	1,637
CVP San Luis Unit	**	1,320
San Luis Interim deliveries	**	60
San Felipe Unit	**	173
Total CVP Delta Exports	**	3350 TAF/Year
Folsom South Canal	**	312 TAF/Year

TABLE C-1 (Continued)
BASIC ASSUMPTIONS AND OPERATION CRITERIA IN STATEWIDE OPERATION STUDIES IN SUPPORT OF NORTH DELTA WATER MANAGEMENT PROGRAM

A. No-Action Study (423 D) (Continued)

- CVP agricultural deficiencies imposed as follows: 25 percent in years 1924, 1929, 1931, 1933, 1934, 1976, and 50 percent in 1977.
- SWP demands based on SWPAO's long-range projections for bulletin 132-88, as tabulated below.

	Entitlement Request (2000 level)
No. Bay Aqueduct	53 TAF/Year
So. Bay Aqueduct (includes reaches 1-2B of the Cal. Aqueduct)	213
SWP Dos Amigos demand	3,505
Total Demands	3,771 TAF/Year
Agricultural portion	1,257
M & I portion	2,445
Recreation & losses	69

- Actual SWP deliveries in any year were based on a risk curve developed for the base study defined by following relationship:

End-of-September Reservoir Carry-over Storage (TAF)	SWP Annual Delivery (TAF)
72	0
500	500
1,000	500
1,000	1,000
1,050	1,500
1,100	1,750
1,180	2,000
1,433	2,300
2,500	3,367
2,811	4,300

B. Preferred and Other Alternatives (420 Series)

All basic assumptions and operation criteria for the alternatives studied are similar to those described for study 423 D except the following:

- New Delta Cross Channel and Georgian Slough Water Transfer Curves were developed for each alternative.

TABLE C-1 (Continued)
BASIC ASSUMPTIONS AND OPERATION CRITERIA IN STATEWIDE OPERATION STUDIES IN SUPPORT OF NORTH DELTA WATER MANAGEMENT PROGRAM

2. 480 Series

A. Base study 2000-SDI-486.f

All assumptions on the facilities and operation criteria were similar to those in the base study 423d, except for the following:

- CVP system operations were maintained identical operation to that in the base study 423D.
- South Delta channel improvements were assumed allowing a 10,300 cfs maximum diversion capacity at theSWP Banks Pumping Plant.

B. Preferred and Other Alternatives (480 Series)

All assumptions on the facilities and operation criteria were similar to those in the base study 486.f , except for the following:

- New Delta Cross Channel and Georgiana Slough Water Transfer Curves were used for each alternative

3. 520 Series

A. Base study 2000-SDI-520

All assumptions on the facilities and operation criteria were similar to those in study 486f, except for the following:

- Kern Water Bank Ground Water Storage Project with the following physical and operational characteristics was incorporated into the SWP system:

a. Total storage capacity was set at 1.0 MAF.

b. Maximum monthly ground water recharge and extraction capacities were 30 TAF/mo.

c. In addition to the maximum direct contribution of the KWB (360 TAF/yr) only 25% of the remaining ground water storage over 360 TAF was counted in the computation of the system carryover storage to determine SWP annual deliveries.

d. Recharge was done at the maximum rate in all years when 100% of the total SWP requests are met. Annual recharge amount was reduced by half in years when the annual delivery to SWP contractors was below 100%, but atleast 85% of the total requests. Extraction at low rate (maximum of 180 TAF/yr) was started when the delivery capability fell between 85% and 70% of the total requests. Extraction at maximum rate was started in years when the delivery capability fell below 70% of the total requests.

e. Initial decision on the annual operation of the KWB either recharge or withdrawal could be overridden as a function of the end-of-month storage in Lake Oroville according to the following parameters:

Oroville Storage (TAF)	Initial Decision	Revised Decision
<1800	High Recharge	Low Recharge
<1750	High or Low Recharge	Do Nothing
<1600	High or Low Recharge	Low Extraction
<1550	High or Low Recharge	High Extraction
>1550	High Extraction	Low Extraction

TABLE C-1 (Continued)
BASIC ASSUMPTIONS AND OPERATION CRITERIA IN STATEWIDE OPERATION STUDIES IN SUPPORT OF NORTH DELTA WATER MANAGEMENT PROGRAM

A. Base study 2000-SDI-520 (Continued)

Oroville Storage (TAF)	Initial Decision	Revised Decision
>1700	High or Low Recharge	Do Nothing
>1750	High or Low Recharge	Low Recharge
>1800	High or Low Recharge	High Recharge

- Los Banos Grandes Reservoir with the following characteristics was incorporated into the SWP system.
  a. Total Storage Capacity of 1.73 MAF.
  b. Inlet/Outlet capacity of 3500 cfs.
- Actual SWP deliveries were based on a risk curve developed for the system with KWB and LBG defined by the following relationship:

End-of-September Total Reservoir Carryover Storage (TAF)	SWP Annual Delivery (TAF)
72	0
500	500
1000	500
1000	1000
1050	1500
1100	1750
1200	2000
1350	2300
1517	2550
3000	3275
3150	3524
3327	4300

- New Delta Cross Channel and Georgiana Slough Water Transfer Curves were used for each alternative

4. 530 Series

A. Base Study 536.f
All assumptions on the facilities and operation criteria were similar to those in the base study 2000-SDI-520, except for the following:

	SWP Entitlement Request (2035 level)
North Bay Aqueduct	67
South Bay Aqueduct (includes Cal. aqueduct reaches 1-2B)	213
SWP Dos Amigos	3967
Total	4247
AG Portion	1269
MI Portion	2909
Rec. & Losses	69

TABLE C-2
PHASE I MODELING
TIDE, DEPLETION AND HYDROLOGY DATA

TIDE BOUNDARY CONDITION

Martinez 19-year mean, 25-hour tide input to the model on a 15-minute basis.

DELTA NET CHANNEL DEPLETIONS

Estimates of historic July 1979 diversion and drainage return data were modified to include additional net channel depletions from the crescent of Middle River (between its head and Victoria Cut) and Tom Paine Slough. Estimates of historic July 1979 were determined using a consumptive use analysis of 142 areas (islands) in the Delta (DWR Delta island consumptive use study, 1987, unpublished), and the 1987 DWR field survey of current diversion siphons and drainage pipes. These values are:

	Diversion	Drainage	Net CD
(cfs)	6159	1626	4533

Net Channel Depletion (CD) is defined as Diversion minus Drainage. For model simulations, diversions and drainage returns were allocated to appropriate model nodes.

NET DELTA OUTFLOW INDEX

The net Delta outflow index is determined by subtracting the sum of all exports and net channel depletions from the sum of all rim inflows. The net Delta outflow indexes for the selected hydrologies are reported below.

DELTA HYDROLOGY BOUNDARY CONDITIONS

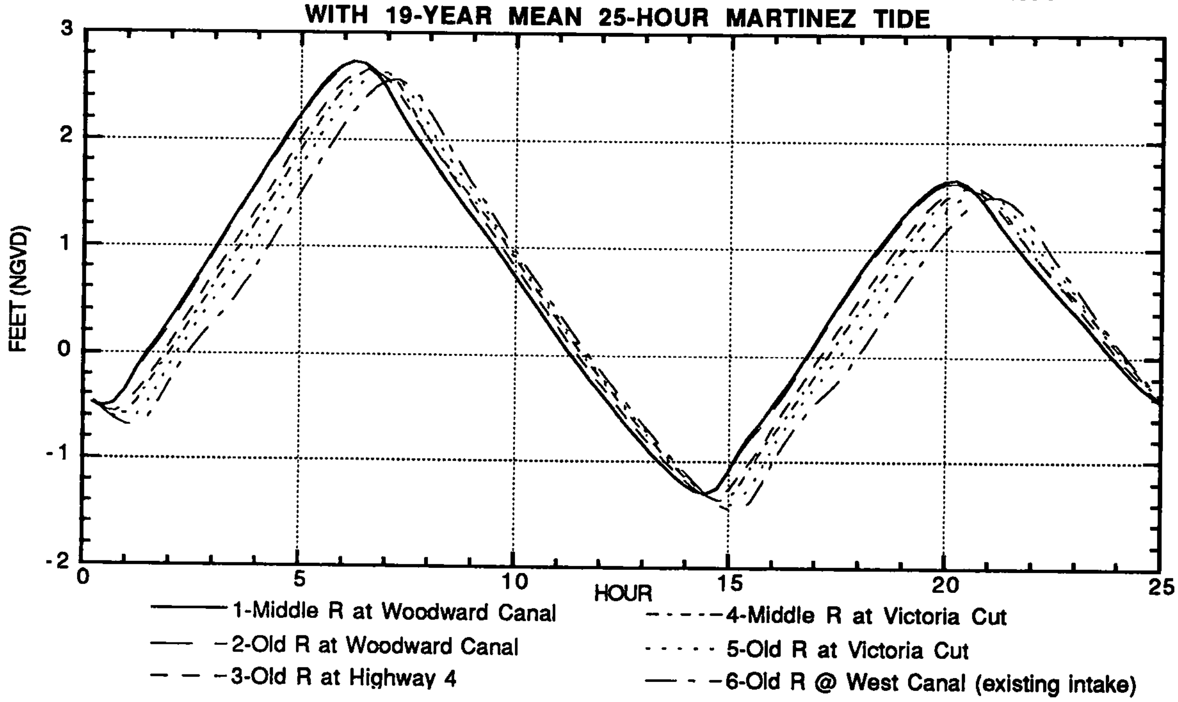
RIM INFLOWS (cubic feet per second)	SET 1	SET 2	SET 3	SET 4	SET 5	SET 6
Sacramento River at Sacramento	11080	16480	20380	22000	22000	22000
San Joaquin River at Vernalis	1500	1500	1500	1500	1500	1500
Calaveras River	170	170	170	170	170	170
Cosumnes River	10	10	10	10	10	10
Mokelumne River + Dry Creek	100	100	100	100	100	100
RIM EXPORTS (cubic feet per second)						
SWP Banks Pumping Plant	1000	6400	10300	1000	6400	10300
CVP Tracy Pumping Plant	4600	4600	4600	4600	4600	4600
Contra Costa Canal	180	180	180	180	180	180
North Bay Aqueduct	50	50	50	50	50	50
NET DELTA OUTFLOW INDEX (cubic feet per second)	2500	2500	2500	13400	8020	4140

TABLE C-3
PHASE I MODELING
SWP FOREBAY GATE OPERATION SCHEDULE

PHASE I GATE OPERATION

GATE OPERATION	TIMING
OPEN	1 HOUR BEFORE HIGH-HIGH TIDE
CLOSE	2 HOURS BEFORE LOW-LOW TIDE
OPEN	1 HOUR AFTER LOW-LOW TIDE
CLOSE	1 HOUR BEFORE HIGH-LOW TIDE

TIDES AT FOREBAY INTAKE LOCATIONS WITHOUT SWP EXPORTS WITH 19-YEAR MEAN 25-HOUR MARTINEZ TIDE



GATE OPERATION SCHEDULE

LOCATION	MODEL NODE	TIME IN HOURS OPEN	CLOSE	OPEN	CLOSE
1	117	5.25	12.25	15.25	24.25
2	82	5.25	12.25	15.25	24.25
3	79	5.25	12.50	15.50	24.50
4	113	5.50	12.50	15.50	24.50
5	75	5.75	12.75	15.75	24.75
6	72	6.00	13.00	16.00	25.00

TABLE C-4
PHASE I MODELING
CONFIGURATION COMPONENTS

ID NUMBER	DESCRIPTION

NORTH DELTA CHANNEL MODIFICATIONS *

1 None.

2 Dredge to elevation -20 feet NGVD: Snodgrass Slough from Delta Cross Channel to Dead Horse Cut; Dead Horse Cut; South Fork Mokelumne River from New Hope Landing To Terminous; Little Potato Slough; and Little Connection Slough.

3 Enlarge channel to achieve minimum 6000 square feet cross-sectional area; dredge to elevation -20 feet NGVD and use levee setback if necessary: Snodgrass Slough from Delta Cross Channel to Dead Horse Cut; Dead Horse Cut; South Fork Mokelumne River from New Hope Landing To Terminous; Little Potato Slough; and Little Connection Slough.

4 Enlarge channel to achieve minimum 8000 square feet cross-sectional area; dredge to elevation -20 feet NGVD and use levee setback if necessary: Snodgrass Slough from Delta Cross Channel to Dead Horse Cut; Dead Horse Cut; South Fork Mokelumne River from New Hope Landing To Terminous; Little Potato Slough; and Little Connection Slough.

5 Enlarge channel to achieve minimum 12000 square feet cross-sectional area; dredge to elevation -20 feet NGVD and use levee setback if necessary: Snodgrass Slough from Delta Cross Channel to Dead Horse Cut; Dead Horse Cut; South Fork Mokelumne River from New Hope Landing To Terminous; Little Potato Slough; and Little Connection Slough.

6 Enlarge channel to achieve minimum16000 square feet cross-sectional area; dredge to elevation -20 feet NGVD and use levee setback if necessary: Snodgrass Slough from Delta Cross Channel to Dead Horse Cut; Dead Horse Cut; South Fork Mokelumne River from New Hope Landing To Terminous; Little Potato Slough; and Little Connection Slough.

7 Dredge to elevation -20 feet NGVD: Snodgrass Slough from Delta Cross Channel to Dead Horse Cut; Dead Horse Cut; and South Fork Mokelumne River from New Hope Landing To Terminous.

8 Dredge to elevation -20 feet NGVD: Snodgrass Slough from Delta Cross Channel to North Fork Mokelumne River; Dead Horse Cut; South Fork Mokelumne River from New Hope Landing To Terminous; Little Potato Slough; Little Connection Slough; and North Fork Mokelumne River from Snodgrass Slough to San Joaquin River.

9 Dredge to elevation -20 feet NGVD: Snodgrass Slough from Delta Cross Channel to North Fork Mokelumne River; Dead Horse Cut; South Fork Mokelumne River from New Hope Landing To Terminous; Little Potato Slough; Little Connection Slough; and North Fork Mokelumne River from South Fork Mokelumne River to San Joaquin River.

10 Dredge to elevation -20 feet NGVD: Snodgrass Slough from Delta Cross Channel to North Fork Mokelumne River; Dead Horse Cut; South Fork Mokelumne River from New Hope Landing To Terminous; Little Potato Slough; Little Connection Slough; North Fork Mokelumne River from Snodgrass Slough to San Joaquin River; and Georgiana Slough.

11 Dredge to elevation -20 feet NGVD: Snodgrass Slough from Delta Cross Channel to North Fork Mokelumne River; and North Fork Mokelumne River from Snodgrass Slough to San Joaquin River.

12 Enlarge channel to achieve minimum 6000 square feet cross-sectional area; dredge to elevation -20 feet NGVD and use levee setback if necessary: Snodgrass Slough from Delta Cross Channel to North Fork Mokelumne River; and North Fork Mokelumne River from Snodgrass Slough to San Joaquin River.

* Flow areas are specified with respect to the water surface elevation (stage) at zero NGVD.

TABLE C-4 (Continued)

ID NUMBER — DESCRIPTION

NORTH DELTA CHANNEL MODIFICATIONS (Continued) *

13 Enlarge channel to achieve minimum 8000 square feet cross-sectional area; dredge to elevation -20 feet NGVD and use levee setback if necessary: Snodgrass Slough from Delta Cross Channel to North Fork Mokelumne River; and North Fork Mokelumne River from Snodgrass Slough to San Joaquin River.

14 Enlarge channel to achieve minimum10000 square feet cross-sectional area; dredge to elevation -20 feet NGVD and use levee setback if necessary: Snodgrass Slough from Delta Cross Channel to North Fork Mokelumne River; and North Fork Mokelumne River from Snodgrass Slough to San Joaquin River.

15 Enlarge channel to achieve minimum 12000 square feet cross-sectional area; dredge to elevation -20 feet NGVD and use levee setback if necessary: Snodgrass Slough from Delta Cross Channel to North Fork Mokelumne River; and North Fork Mokelumne River from Snodgrass Slough to San Joaquin River.

16 Enlarge channel to achieve minimum 16000 square feet cross-sectional area; dredge to elevation -20 feet NGVD and use levee setback if necessary: Snodgrass Slough from Delta Cross Channel to North Fork Mokelumne River; and North Fork Mokelumne River from Snodgrass Slough to San Joaquin River.

17 Dredge to elevation -20 feet NGVD: Snodgrass Slough from Delta Cross Channel to Dead Horse Cut; Dead Horse Cut; South Fork Mokelumne River from New Hope Landing To San Joaquin River.

18 Enlarge channel to achieve minimum 8000 square feet cross-sectional area; dredge to elevation -20 feet NGVD and use levee setback if necessary: Snodgrass Slough from Delta Cross Channel to Dead Horse Cut; Dead Horse Cut; South Fork Mokelumne River from New Hope Landing To San Joaquin River.

19 Enlarge channel to achieve minimum 10000 square feet cross-sectional area; dredge to elevation -20 feet NGVD and use levee setback if necessary: Snodgrass Slough from Delta Cross Channel to Dead Horse Cut; Dead Horse Cut; South Fork Mokelumne River from New Hope Landing To San Joaquin River.

20 Floodway from Dead Horse Island to lower South Fork Mokelumne R. comprised of Staten Island.

21 Floodway from Dead Horse Island to San Joaquin River comprised of: Staten Island, northwestern corner of Bouldin Island; southeastern corner of Andrus Island; and Mokelumne River from Georgiana Slough confluence to San Joaquin River.

DELTA CROSS CHANNEL FLOW CAPACITY

1 Existing facility with 1 gate open; 810 square feet flow area.

2 Existing facility with 2 gates open; 1620 square feet flow area.

3 Enlarged facility with 3 gates open; 2430 square feet flow area.

4 Enlarged facility with 4 gates open; 3240 square feet flow area.

5 Enlarged facility with full channel flow; 4500 square feet flow area.

* Flow areas are specified with respect to the water surface elevation (stage) at zero NGVD.

TABLE C-5
PHASE I MODELING
ALTERNATIVE NORTH DELTA CONFIGURATIONS

ID NUMBER	SERIES ID	CHANNEL MODIFICATION	DELTA CROSS CHANNEL CAPACITY
1	A01	1	2
2	A02	2	2
3	A03	3	2
4	A04	4	2
5	A05	5	2
6	A06	6	2
7	A07	7	2
8	A08	8	2
9	A09	9	2
10	A10	10	2
11	A11	9	5
12	A12	11	2
13	A13	12	2
14	A14	13	2
15	A15	15	2
16	A16	16	2
17	A17	2	3
18	A18	3	3
19	A19	4	3
20	A20	5	3
21	A21	6	3
22	A22	1	1
23	A23	1	3
24	A24	1	5
25	A25	2	5
26	A26	9	3
27	A27	9	4
28	A28	2, 13	2
29	A29	2, 13	3
30	A30	2, 13	4
31	A31	2,13	5
32	A32	2, 14	2
33	A33	2, 14	5
34	A34	4	5
35	A35	17	2
36	A36	18	2
37	A37	19	2
38	A38	19	5
39	A39	20	2
40	A40	20	5
41	A41	21	2
42	A42	21	5

TABLE C-6
PHASE II MODELING
ALTERNATIVE NORTH DELTA CONFIGURATIONS

CONFIGURATION ID NUMBER	ALTERNATIVE ID NUMBER (CHAPTER 5)	CHANNEL MODIFICATION ID (TABLE C-4)	DELTA CROSS CHANNEL CAPACITY (TABLE C-4)	FOREBAY *	FOREBAY INTAKE LOCATION
NO ACTION (BASE CASE)	1	1	2	EXISTING	EXISTING
1	2A	2	2	EXISTING	EXISTING
2	None	2	2	VICTORIA+BYRON+ CLIFTON COURT	MIDDLE RIVER AT WOODWARD CANAL
3	3B	9	5	EXISTING	EXISTING
4	None	9	5	VICTORIA+BYRON+ CLIFTON COURT	MIDDLE RIVER AT WOODWARD CANAL
5	None	4	3	EXISTING	EXISTING
6	None	4	3	VICTORIA+BYRON+ CLIFTON COURT	MIDDLE RIVER AT WOODWARD CANAL

* Additional South Delta facilities are included with the Victoria-Byron-Clifton Court Forebay as described in the Alternative North Delta Configurations Section under Phase II Delta Modeling.

TABLE C-7
PHASE II MODELING
MONTHLY AVERAGE TOTAL DISSOLVED SOLIDS IN PPM AT ANTIOCH

REPRESENTATIVE CRITICAL YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	171	90	172	620	985	953	1224	1310	1524	1555	1779	2002
2A	144	82	150	543	1219	1386	1336	1174	1365	1244	1669	2207
2B	92	78	117	421	964	1392	1170	896	1032	940	1325	2173
3A	144	82	150	543	1219	1386	1336	1174	1365	1244	1669	2207
3B	102	78	126	452	1018	1472	1226	936	1080	959	1321	2219
4A	144	82	150	543	1219	1386	1336	1174	1365	1244	1669	2207
4B	102	78	126	452	1018	1472	1226	936	1080	959	1321	2219
5A	144	82	150	543	1219	1386	1336	1174	1365	1244	1669	2207
5B	102	78	126	452	1018	1472	1226	936	1080	959	1321	2219
6A	92	78	117	421	964	1392	1170	896	1032	940	1325	2173
6B	102	78	126	452	1018	1472	1226	936	1080	959	1321	2219

REPRESENTATIVE DRY YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	995	283	376	284	316	675	486	269	304	507	1062	1525
2A	1243	253	412	296	340	789	449	213	252	619	1077	1714
2B	1168	126	335	258	369	670	269	157	190	446	811	1851
3A	1243	253	412	296	340	789	449	213	252	619	1077	1714
3B	1229	146	354	268	397	691	312	165	194	453	833	1924
4A	1243	253	412	296	340	789	449	213	252	619	1077	1714
4B	1229	146	354	268	397	691	312	165	194	453	833	1924
5A	1243	253	412	296	340	789	449	213	252	619	1077	1714
5B	1229	146	354	268	397	691	312	165	194	453	833	1924
6A	1168	126	335	258	369	670	269	157	190	446	811	1851
6B	1229	146	354	268	397	691	312	165	194	453	833	1924

REPRESENTATIVE BELOW NORMAL YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	449	559	248	131	116	134	226	204	229	370	498	786
2A	492	407	150	115	110	130	174	159	191	298	486	977
2B	382	209	91	110	109	121	145	140	152	196	438	1202
3A	492	407	150	115	110	130	174	159	191	298	486	977
3B	559	227	96	110	108	117	143	147	154	213	520	1546
4A	492	407	150	115	110	130	174	159	191	298	486	977
4B	559	227	96	110	108	117	143	147	154	213	520	1546
5A	492	407	150	115	110	130	174	159	191	298	486	977
5B	559	227	96	110	108	117	143	147	154	213	520	1546
6A	382	209	91	110	109	121	145	140	152	196	438	1202
6B	559	227	96	110	108	117	143	147	154	213	520	1546

REPRESENTATIVE ABOVE NORMAL YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	371	167	109	114	105	80	84	85	85	133	228	502
2A	345	122	95	111	107	80	84	85	85	120	230	546
2B	206	84	86	109	108	81	84	86	85	104	205	417
3A	345	122	95	111	107	80	84	85	85	120	230	546
3B	243	86	87	110	103	80	84	85	84	106	244	476
4A	345	122	95	111	107	80	84	85	85	120	230	546
4B	243	86	87	110	103	80	84	85	84	106	244	476
5A	345	122	95	111	107	80	84	85	85	120	230	546
5B	243	86	87	110	103	80	84	85	84	106	244	476
6A	206	84	86	109	108	81	84	86	85	104	205	417
6B	243	86	87	110	103	80	84	85	84	106	244	476

REPRESENTATIVE WET YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	2016	2497	2138	132	115	128	112	101	90	92	176	525
2A	1825	2246	2257	132	122	128	112	102	90	91	186	656
2B	1608	1890	2352	129	123	127	111	101	90	90	1723	871
3A	1825	2246	2257	132	122	128	112	102	90	91	186	656
3B	1613	1867	2607	127	120	131	113	99	89	89	212	1166
4A	1825	2246	2257	132	122	128	112	102	90	91	186	656
4B	1613	1867	2607	127	120	131	113	99	89	89	212	1166
5A	1825	2246	2257	132	122	128	112	102	90	91	186	656
5B	1613	1867	2607	127	120	131	113	99	89	89	212	1166
6A	1608	1890	2352	129	123	127	111	101	90	90	1723	871
6B	1613	1867	2607	127	120	131	113	99	89	89	212	1166

DESCRIPTION OF ALTERNATIVES:

- 1 No-Action
- 2A Dredge So. Frk. Mok.
- 2B Dredge So. Frk. Mok.,4500sf DXC
- 3A Dredge NFK, SFK Mok.
- 3B Dredge NFK, SFK Mok., 4500sf DXC
- 4A 6-8-10k SFK. Mok., Dredge NFK Mok.
- 4B 6-8-10k SFK. Mok., Dredge NFK Mok., 4500sf DXC
- 5A 6-8-14 NFK. Mok.,Dredge SFK. Mok.
- 5B 6-8-14 NFK. Mok.,Dredge SFK. Mok., 4500sf DXC
- 6A Staten Island Floodway
- 6B Staten Island Floodway, 4500sf DXC

TABLE C-8
PHASE II MODELING
MONTHLY AVERAGE TOTAL DISSOLVED SOLIDS IN PPM AT PRISONERS POINT

REPRESENTATIVE CRITICAL YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	77	75	80	81	85	90	95	93	87	85	85	88
2A	76	75	80	82	85	90	95	94	86	81	82	86
2B	77	76	82	83	83	84	91	96	87	81	80	83
3A	76	75	80	82	85	90	95	94	86	81	82	86
3B	76	75	80	81	82	83	88	89	82	78	79	82
4A	76	75	80	82	85	90	95	94	86	81	82	86
4B	76	75	80	81	82	83	88	89	82	78	79	82
5A	76	75	80	82	85	90	95	94	86	81	82	86
5B	76	75	80	81	82	83	88	89	82	78	79	82
6A	77	76	82	83	83	84	91	96	87	81	80	83
6B	76	75	80	81	82	83	88	89	82	78	79	82

REPRESENTATIVE DRY YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	81	76	86	86	84	84	86	86	81	79	82	85
2A	82	76	86	87	85	84	84	88	82	79	81	84
2B	81	76	91	84	83	83	84	91	85	79	80	83
3A	82	76	86	87	85	84	84	88	82	79	81	84
3B	81	75	88	85	82	81	82	86	81	78	78	81
4A	82	76	86	87	85	84	84	88	82	79	81	84
4B	81	75	88	85	82	81	82	86	81	78	78	81
5A	82	76	86	87	85	84	84	88	82	79	81	84
5B	81	75	88	85	82	81	82	86	81	78	78	81
6A	81	76	91	84	83	83	84	91	85	79	80	83
6B	81	75	88	85	82	81	82	86	81	78	78	81

REPRESENTATIVE BELOW NORMAL YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	77	79	81	82	83	80	84	86	81	78	80	81
2A	77	78	80	81	82	80	83	89	82	78	78	80
2B	77	77	79	81	81	80	85	92	85	78	77	80
3A	77	78	80	81	82	80	83	89	82	78	78	80
3B	77	77	79	81	83	79	82	87	80	77	77	80
4A	77	78	80	81	82	80	83	89	82	78	78	80
4B	77	77	79	81	83	79	82	87	80	77	77	80
5A	77	78	80	81	82	80	83	89	82	78	78	80
5B	77	77	79	81	83	79	82	87	80	77	77	80
6A	77	77	79	81	81	80	85	92	85	78	77	80
6B	77	77	79	81	83	79	82	87	80	77	77	80

REPRESENTATIVE ABOVE NORMAL YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	77	77	80	107	121	78	82	83	79	77	77	80
2A	76	76	79	107	123	80	82	86	80	77	77	79
2B	76	76	79	107	126	80	80	85	83	78	77	79
3A	76	76	79	107	123	80	82	86	80	77	77	79
3B	76	76	79	106	116	78	81	83	79	77	77	78
4A	76	76	79	107	123	80	82	86	80	77	77	79
4B	76	76	79	106	116	78	81	83	79	77	77	78
5A	76	76	79	107	123	80	82	86	80	77	77	79
5B	76	76	79	106	116	78	81	83	79	77	77	78
6A	76	76	79	107	126	80	80	85	83	78	77	79
6B	76	76	79	106	116	78	81	83	79	77	77	78

REPRESENTATIVE WET YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	84	82	149	109	175	168	142	98	92	78	77	78
2A	83	80	146	137	183	161	137	100	93	80	77	79
2B	82	78	140	149	186	159	134	94	90	80	77	79
3A	83	80	146	137	183	161	137	100	93	80	77	79
3B	81	78	136	139	204	179	148	98	90	78	77	79
4A	83	80	146	137	183	161	137	100	93	80	77	79
4B	81	78	136	139	204	179	148	98	90	78	77	79
5A	83	80	146	137	183	161	137	100	93	80	77	79
5B	81	78	136	139	204	179	148	98	90	78	77	79
6A	82	78	140	149	186	159	134	94	90	80	77	79
6B	81	78	136	139	204	179	148	98	90	78	77	79

DESCRIPTION OF ALTERNATIVES

- 1 No-Action
- 2A Dredge So. Frk. Mok.
- 2B Dredge So. Frk. Mok.,4500sf DXC
- 3A Dredge NFK, SFK Mok.
- 3B Dredge NFK, SFK Mok., 4500sf DXC
- 4A 6-8-10k SFK. Mok., Dredge NFK Mok.
- 4B 6-8-10k SFK. Mok., Dredge NFK Mok., 4500sf DXC
- 5A 6-8-14 NFK. Mok.,Dredge SFK. Mok.
- 5B 6-8-14 NFK. Mok.,Dredge SFK. Mok., 4500sf DXC
- 6A Staten Island Floodway
- 6B Staten Island Floodway, 4500sf DXC

TABLE C-9
PHASE II MODELING
MONTHLY AVERAGE TOTAL DISSOLVED SOLIDS IN PPM AT ROCK SLOUGH

REPRESENTATIVE CRITICAL YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	84	77	86	94	116	159	168	151	145	149	143	153
2A	82	77	86	93	111	157	166	143	128	122	119	142
2B	79	77	87	92	106	122	135	127	117	106	104	126
3A	82	77	86	93	111	157	166	143	128	122	119	142
3B	79	77	86	92	105	125	138	127	115	105	104	127
4A	82	77	86	93	111	157	166	143	128	122	119	142
4B	79	77	86	92	105	125	138	127	115	105	104	127
5A	82	77	86	93	111	157	166	143	128	122	119	142
5B	79	77	86	92	105	125	138	127	115	105	104	127
6A	79	77	87	92	106	122	135	127	117	106	104	126
6B	79	77	86	92	105	125	138	127	115	105	104	127

REPRESENTATIVE DRY YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	94	88	90	113	106	124	131	114	105	101	112	127
2A	95	86	89	111	106	120	124	112	104	98	110	125
2B	93	80	88	105	100	110	113	109	104	92	95	113
3A	95	86	89	111	106	120	124	112	104	98	110	125
3B	96	81	87	105	100	111	113	108	102	91	95	115
4A	95	86	89	111	106	120	124	112	104	98	110	125
4B	96	81	87	105	100	111	113	108	102	91	95	115
5A	95	86	89	111	106	120	124	112	104	98	110	125
5B	96	81	87	105	100	111	113	108	102	91	95	115
6A	93	80	88	105	100	110	113	109	104	92	95	113
6B	96	81	87	105	100	111	113	108	102	91	95	115

REPRESENTATIVE BELOW NORMAL YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	89	91	95	91	100	107	115	116	103	97	103	106
2A	87	83	88	88	97	106	114	116	103	93	93	102
2B	83	78	85	87	96	106	113	116	103	91	86	96
3A	87	83	88	88	97	106	114	116	103	93	93	102
3B	89	79	85	86	96	104	113	115	101	90	87	104
4A	87	83	88	88	97	106	114	116	103	93	93	102
4B	89	79	85	86	96	104	113	115	101	90	87	104
5A	87	83	88	88	97	106	114	116	103	93	93	102
5B	89	79	85	86	96	104	113	115	101	90	87	104
6A	83	78	85	87	96	106	113	116	103	91	86	96
6B	89	79	85	86	96	104	113	115	101	90	87	104

REPRESENTATIVE ABOVE NORMAL YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	88	80	83	102	170	116	102	108	97	90	90	97
2A	84	78	83	102	170	115	103	109	97	90	88	93
2B	79	77	82	101	173	114	102	108	97	90	86	88
3A	84	78	83	102	170	115	103	109	97	90	88	93
3B	79	77	82	100	171	117	103	1208	96	89	86	89
4A	84	78	83	102	170	115	103	109	97	90	88	93
4B	79	77	82	100	171	117	103	1208	96	89	86	89
5A	84	78	83	102	170	115	103	109	97	90	88	93
5B	79	77	82	100	171	117	103	1208	96	89	86	89
6A	79	77	82	101	173	114	102	108	97	90	86	88
6B	79	77	82	100	171	117	103	1208	96	89	86	89

REPRESENTATIVE WET YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	157	148	242	313	281	370	233	139	134	99	87	90
2A	143	138	227	323	310	415	234	138	133	99	87	90
2B	134	130	213	320	322	419	229	135	130	96	87	90
3A	143	138	227	323	310	415	234	138	133	99	87	90
3B	136	132	218	318	323	418	236	138	132	96	86	93
4A	143	138	227	323	310	415	234	138	133	99	87	90
4B	136	132	218	318	323	418	236	138	132	96	86	93
5A	143	138	227	323	310	415	234	138	133	99	87	90
5B	136	132	218	318	323	418	236	138	132	96	86	93
6A	134	130	213	320	322	419	229	135	130	96	87	90
6B	136	132	218	318	323	418	236	138	132	96	86	93

DESCRIPTION OF ALTERNATIVES

1	No-Action
2A	Dredge So. Frk. Mok.
2B	Dredge So. Frk. Mok.,4500sf DXC
3A	Dredge NFK, SFK Mok.
3B	Dredge NFK, SFK Mok., 4500sf DXC
4A	6-8-10k SFK. Mok., Dredge NFK Mok.
4B	6-8-10k SFK. Mok., Dredge NFK Mok., 4500sf DXC
5A	6-8-14 NFK. Mok.,Dredge SFK. Mok.
5B	6-8-14 NFK. Mok.,Dredge SFK. Mok., 4500sf DXC
6A	Staten Island Floodway
6B	Staten Island Floodway, 4500sf DXC

TABLE C-10
PHASE II MODELING
MONTHLY AVERAGE TOTAL DISSOLVED SOLIDS IN PPM AT CLIFTON COURT

REPRESENTATIVE CRITICAL YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	164	165	169	182	165	197	236	247	217	183	212	227
2A	165	170	170	179	170	194	235	246	208	172	201	221
2B	162	172	172	178	165	173	221	237	198	164	193	213
3A	165	170	170	179	170	194	235	246	208	172	201	221
3B	163	174	180	188	167	182	222	237	200	163	192	214
4A	165	170	170	179	170	194	235	246	208	172	201	221
4B	163	174	180	188	167	182	222	237	200	163	192	214
5A	165	170	170	179	170	194	235	246	208	172	201	221
5B	163	174	180	188	167	182	222	237	200	163	192	214
6A	162	172	172	178	165	173	221	237	198	164	193	213
6B	163	174	180	188	167	182	222	237	200	163	192	214

REPRESENTATIVE DRY YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	161	169	170	190	174	169	170	214	183	131	144	177
2A	162	166	175	183	174	165	166	214	181	129	144	171
2B	162	161	173	185	172	170	156	210	180	120	141	164
3A	162	166	175	183	174	165	166	214	181	129	144	171
3B	164	161	173	186	172	171	156	211	179	127	139	164
4A	162	166	175	183	174	165	166	214	181	129	144	171
4B	164	161	173	186	172	171	156	211	179	127	139	164
5A	162	166	175	183	174	165	166	214	181	129	144	171
5B	164	161	173	186	172	171	156	211	179	127	139	164
6A	162	161	173	185	172	170	156	210	180	120	141	164
6B	164	161	173	186	172	171	156	211	179	127	139	164

REPRESENTATIVE BELOW NORMAL YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	155	161	170	1283	175	142	159	231	189	128	140	167
2A	154	158	165	178	175	149	158	231	188	125	125	155
2B	151	159	165	176	174	146	166	230	187	127	117	152
3A	154	158	165	178	175	149	158	231	188	125	125	155
3B	160	159	166	187	177	147	166	229	188	125	115	156
4A	154	158	165	178	175	149	158	231	188	125	125	155
4B	160	159	166	187	177	147	166	229	188	125	115	156
5A	154	158	165	178	175	149	158	231	188	125	125	155
5B	160	159	166	187	177	147	166	229	188	125	115	156
6A	151	159	165	176	174	146	166	230	187	127	117	152
6B	160	159	166	187	177	147	166	229	188	125	115	156

REPRESENTATIVE ABOVE NORMAL YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	161	166	168	201	189	174	162	199	139	123	93	146
2A	157	177	166	202	188	173	163	198	139	124	89	144
2B	154	170	171	197	189	169	163	198	138	120	85	152
3A	157	177	166	202	188	173	163	198	139	124	89	144
3B	157	174	179	203	190	176	164	199	138	123	92	152
4A	157	177	166	202	188	173	163	198	139	124	89	144
4B	157	174	179	203	190	176	164	199	138	123	92	152
5A	157	177	166	202	188	173	163	198	139	124	89	144
5B	157	174	179	203	190	176	164	199	138	123	92	152
6A	154	170	171	197	189	169	163	198	138	120	85	152
6B	157	174	179	203	190	176	164	199	138	123	92	152

REPRESENTATIVE WET YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	307	237	238	241	248	174	155	240	262	220	143	153
2A	301	234	219	261	259	174	155	239	262	219	143	152
2B	296	227	203	267	262	174	155	239	260	218	142	150
3A	301	234	219	261	259	174	155	239	262	219	143	152
3B	295	229	213	264	262	175	155	240	261	218	141	151
4A	301	234	219	261	259	174	155	239	262	219	143	152
4B	295	229	213	264	262	175	155	240	261	218	141	151
5A	301	234	219	261	259	174	155	239	262	219	143	152
5B	295	229	213	264	262	175	155	240	261	218	141	151
6A	296	227	203	267	262	174	155	239	260	218	142	150
6B	295	229	213	264	262	175	155	240	261	218	141	151

DESCRIPTION OF ALTERNATIVES

- 1 No-Action
- 2A Dredge So. Frk. Mok.
- 2B Dredge So. Frk. Mok.,4500sf DXC
- 3A Dredge NFK, SFK Mok.
- 3B Dredge NFK, SFK Mok., 4500sf DXC
- 4A 6-8-10k SFK. Mok., Dredge NFK Mok.
- 4B 6-8-10k SFK. Mok., Dredge NFK Mok., 4500sf DXC
- 5A 6-8-14 NFK. Mok.,Dredge SFK. Mok.
- 5B 6-8-14 NFK. Mok.,Dredge SFK. Mok., 4500sf DXC
- 6A Staten Island Floodway
- 6B Staten Island Floodway, 4500sf DXC

TABLE C-10A
PHASE II MODELING
MONTHLY AVERAGE TOTAL DISSOLVED SOLIDS IN PPM AT EMMATON

REPRESENTATIVE CRITICAL YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	85	82	129	440	345	303	662	877	784	905	1171	1277
2A	85	81	130	469	574	484	778	964	851	853	1262	1618
2B	83	80	139	537	686	714	915	1033	946	932	1366	2011
3A	85	81	130	469	574	484	778	964	851	853	1262	1618
3B	84	79	139	536	678	716	934	1045	956	941	1374	1977
4A	85	81	130	469	574	484	778	964	851	853	1262	1618
4B	84	79	139	536	678	716	934	1045	956	941	1374	1977
5A	85	81	130	469	574	484	778	964	851	853	1262	1618
5B	84	79	139	536	678	716	934	1045	956	941	1374	1977
6A	83	80	139	537	686	714	915	1033	946	932	1366	2011
6B	84	79	139	536	678	716	934	1045	956	941	1374	1977

REPRESENTATIVE DRY YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	510	90	212	91	160	229	202	204	212	188	684	879
2A	665	92	277	92	210	298	207	193	214	233	787	1083
2B	871	88	315	90	281	352	214	207	233	257	760	1475
3A	665	92	277	92	210	298	207	193	214	233	787	1083
3B	859	88	305	91	287	327	210	203	232	245	766	1471
4A	665	92	277	92	210	298	207	193	214	233	787	1083
4B	859	88	305	91	287	327	210	203	232	245	766	1471
5A	665	92	277	92	210	298	207	193	214	233	787	1083
5B	859	88	305	91	287	327	210	203	232	245	766	1471
6A	871	88	315	90	281	352	214	207	233	257	760	1475
6B	859	88	305	91	287	327	210	203	232	245	766	1471

REPRESENTATIVE BELOW NORMAL YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	166	223	100	85	84	83	149	192	167	144	204	513
2A	181	197	94	84	83	82	143	191	164	142	215	664
2B	212	174	92	83	83	81	155	194	174	144	254	956
3A	181	197	94	84	83	82	143	191	164	142	215	664
3B	226	167	91	83	83	81	148	195	173	141	269	1114
4A	181	197	94	84	83	82	143	191	164	142	215	664
4B	226	167	91	83	83	81	148	195	173	141	269	1114
5A	181	197	94	84	83	82	143	191	164	142	215	664
5B	226	167	91	83	83	81	148	195	173	141	269	1114
6A	212	174	92	83	83	81	155	194	174	144	254	956
6B	226	167	91	83	83	81	148	195	173	141	269	1114

REPRESENTATIVE ABOVE NORMAL YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	161	95	90	110	87	80	79	78	78	92	105	215
2A	169	92	90	110	87	80	79	78	78	95	114	256
2B	180	87	92	110	87	80	79	79	78	97	136	295
3A	161	95	90	110	87	80	79	78	78	92	105	215
3B	180	85	92	110	87	80	79	79	78	95	145	290
4A	161	95	90	110	87	80	79	78	78	92	105	215
4B	180	85	92	110	87	80	79	79	78	95	145	290
5A	161	95	90	110	87	80	79	78	78	92	105	215
5B	180	85	92	110	87	80	79	79	78	95	145	290
6A	180	87	92	110	87	80	79	79	78	97	136	295
6B	180	85	92	110	87	80	79	79	78	95	145	290

REPRESENTATIVE WET YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	2277	1879	643	114	88	88	80	84	80	85	115	302
2A	2396	1996	818	114	88	88	80	84	80	86	133	416
2B	2475	2181	1147	114	88	88	80	86	81	87	160	640
3A	2396	1996	818	114	88	88	80	84	80	86	133	416
3B	2532	2171	1186	114	88	88	80	85	80	87	174	757
4A	2396	1996	818	114	88	88	80	84	80	86	133	416
4B	2532	2171	1186	114	88	88	80	85	80	87	174	757
5A	2396	1996	818	114	88	88	80	84	80	86	133	416
5B	2532	2171	1186	114	88	88	80	85	80	87	174	757
6A	2475	2181	1147	114	88	88	80	86	81	87	160	640
6B	2532	2171	1186	114	88	88	80	85	80	87	174	757

DESCRIPTION OF ALTERNATIVES

1 No-Action
2A Dredge So. Frk. Mok.
2B Dredge So. Frk. Mok.,4500sf DXC
3A Dredge NFK, SFK Mok.
3B Dredge NFK, SFK Mok., 4500sf DXC
4A 6-8-10k SFK. Mok., Dredge NFK Mok.
4B 6-8-10k SFK. Mok., Dredge NFK Mok., 4500sf DXC
5A 6-8-14 NFK. Mok.,Dredge SFK. Mok.
5B 6-8-14 NFK. Mok.,Dredge SFK. Mok., 4500sf DXC
6A Staten Island Floodway
6B Staten Island Floodway, 4500sf DXC

TABLE C-10B
PHASE II MODELING
MONTHLY AVERAGE TOTAL DISSOLVED SOLIDS IN PPM AT TRACY PUMPING PLANT

REPRESENTATIVE CRITICAL YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	196	190	198	203	207	224	237	245	201	169	201	219
2A	195	190	198	202	202	222	237	241	193	156	190	212
2B	194	190	198	201	198	207	223	232	185	146	181	204
3A	195	190	198	202	202	222	237	241	193	156	190	212
3B	194	190	197	201	199	209	225	233	185	146	181	205
4A	195	190	198	202	202	222	237	241	193	156	190	212
4B	194	190	197	201	199	209	225	233	185	146	181	205
5A	195	190	198	202	202	222	237	241	193	156	190	212
5B	194	190	197	201	199	209	225	233	185	146	181	205
6A	194	190	198	201	198	207	223	232	185	146	181	204
6B	194	190	197	201	199	209	225	233	185	146	181	205

REPRESENTATIVE DRY YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	189	199	202	221	209	208	201	203	168	139	145	179
2A	192	198	203	220	210	207	197	202	167	138	145	180
2B	190	195	202	217	206	201	191	199	164	134	139	176
3A	192	198	203	220	210	207	197	202	167	138	145	180
3B	191	195	201	218	207	202	192	198	164	134	139	176
4A	192	198	203	220	210	207	197	202	167	138	145	180
4B	191	195	201	218	207	202	192	198	164	134	139	176
5A	192	198	203	220	210	207	197	202	167	138	145	180
5B	191	195	201	218	207	202	192	198	164	134	139	176
6A	190	195	202	217	206	201	191	199	164	134	139	176
6B	191	195	201	218	207	202	192	198	164	134	139	176

REPRESENTATIVE BELOW NORMAL YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	192	237	236	217	201	201	195	223	157	133	142	173
2A	190	193	198	203	207	194	200	226	174	143	151	186
2B	187	190	197	203	207	193	199	226	172	141	148	185
3A	190	193	198	203	207	194	200	226	174	143	151	186
3B	190	191	196	202	207	192	198	226	172	141	149	188
4A	190	193	198	203	207	194	200	226	174	143	151	186
4B	190	191	196	202	207	192	198	226	172	141	149	188
5A	190	193	198	203	207	194	200	226	174	143	151	186
5B	190	191	196	202	207	192	198	226	172	141	149	188
6A	187	190	197	203	207	193	199	226	172	141	148	185
6B	190	191	196	202	207	192	198	226	172	141	149	188

REPRESENTATIVE ABOVE NORMAL YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	193	208	211	193	193	204	203	194	127	145	153	184
2A	188	191	191	208	194	208	204	187	132	142	155	188
2B	185	191	191	207	194	207	204	185	130	142	154	185
3A	188	191	191	208	194	208	204	187	132	142	155	188
3B	186	190	191	206	195	209	204	185	130	141	154	186
4A	188	191	191	208	194	208	204	187	132	142	155	188
4B	186	190	191	206	195	209	204	185	130	141	154	186
5A	188	191	191	208	194	208	204	187	132	142	155	188
5B	186	190	191	206	195	209	204	185	130	141	154	186
6A	185	191	191	207	194	207	204	185	130	142	154	185
6B	186	190	191	206	195	209	204	185	130	141	154	186

REPRESENTATIVE WET YEAR

ALT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP
1	311	229	260	260	258	189	166	246	274	214	160	186
2A	308	224	253	271	271	188	166	244	274	214	159	187
2B	306	219	246	272	273	189	166	244	273	211	159	187
3A	308	224	253	271	271	188	166	244	274	214	159	187
3B	307	221	249	269	273	188	166	245	274	211	159	188
4A	308	224	253	271	271	188	166	244	274	214	159	187
4B	307	221	249	269	273	188	166	245	274	211	159	188
5A	308	224	253	271	271	188	166	244	274	214	159	187
5B	307	221	249	269	273	188	166	245	274	211	159	188
6A	306	219	246	272	273	189	166	244	273	211	159	187
6B	307	221	249	269	273	188	166	245	274	211	159	188

DESCRIPTION OF ALTERNATIVES

- 1 No-Action
- 2A Dredge So. Frk. Mok.
- 2B Dredge So. Frk. Mok.,4500sf DXC
- 3A Dredge NFK, SFK Mok.
- 3B Dredge NFK, SFK Mok., 4500sf DXC
- 4A 6-8-10k SFK. Mok., Dredge NFK Mok.
- 4B 6-8-10k SFK. Mok., Dredge NFK Mok., 4500sf DXC
- 5A 6-8-14 NFK. Mok.,Dredge SFK. Mok.
- 5B 6-8-14 NFK. Mok.,Dredge SFK. Mok., 4500sf DXC
- 6A Staten Island Floodway
- 6B Staten Island Floodway, 4500sf DXC

TABLE C-11
RATIO OF DELTA CROSS CHANNEL AND GEORGIANA SLOUGH FLOWS TO SACRAMENTO RIVER FLOW
(MONTHLY AVERAGE FLOWS IN CUBIC FEET PER SECOND)

REPRESENTATIVE CRITICAL YEAR

Alternative		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No-Action	Sacramento R.	20699	19764	16065	10765	15088	16145	11213	10281	11322	10589	9010	8868
	Delta Cross Cl	4423	4683	4080	3262	4111	4319	3308	3089	3366	3191	2872	2822
	Georgiana Sl	2454	2351	2104	1651	2030	2118	1686	1549	1653	1568	1448	1444
	Ratio	0.33	0.36	0.38	0.46	0.41	0.40	0.45	0.45	0.44	0.45	0.48	0.48
2A	Sacramento R.	20700	20215	16065	10765	13387	15228	11430	10282	11289	11137	9010	8868
	Delta Cross Cl	5659	5927	5126	4062	4749	5193	4182	3825	4153	4089	3563	3535
	Georgiana Sl	2290	2225	1955	1513	1753	1907	1568	1413	1512	1489	1318	1322
	Ratio	0.38	0.40	0.44	0.52	0.49	0.47	0.50	0.51	0.50	0.50	0.54	0.55
2B	Sacramento R.	20700	20800	16100	10800	13200	14500	11600	10300	11300	11250	9000	8860
	Delta Cross Cl	7250	7550	6400	4950	5800	6200	5150	4650	5050	5050	4300	4300
	Georgiana Sl	2080	2070	1770	1360	1570	1680	1420	1270	1350	1340	1170	1180
	Ratio	0.45	0.46	0.51	0.58	0.56	0.54	0.57	0.57	0.57	0.57	0.61	0.62
3A	Sacramento R.	20700	20300	16100	10800	13350	15050	11450	10300	11300	11150	9000	8860
	Delta Cross Cl	6100	6350	5450	4300	5050	5450	4450	4050	4400	4350	3750	3750
	Georgiana Sl	2240	2180	1910	1480	1710	1850	1530	1380	1470	1450	1280	1290
	Ratio	0.40	0.42	0.46	0.54	0.51	0.49	0.52	0.53	0.52	0.52	0.56	0.57
3B	Sacramento R.	20700	21114	16064	10765	13190	14453	11547	10282	11289	11234	9010	8867
	Delta Cross Cl	7230	7794	6551	5147	6001	6435	5351	4828	5258	5223	4481	4467
	Georgiana Sl	2173	2148	1830	1391	1608	1719	1457	1293	1383	1370	1199	1210
	Ratio	0.45	0.47	0.52	0.61	0.58	0.56	0.59	0.60	0.59	0.59	0.63	0.64
4A	Sacramento R.	20700	20400	16100	10800	13300	15000	11450	10300	11300	11180	9000	8860
	Delta Cross Cl	6150	6450	5600	4350	5100	5500	4500	4100	4450	4400	3800	3800
	Georgiana Sl	2220	2170	1890	1470	1700	1830	1520	1370	1460	1440	1270	1280
	Ratio	0.40	0.42	0.46	0.54	0.51	0.49	0.53	0.53	0.52	0.52	0.56	0.57
4B	Sacramento R.	20700	21400	16100	10800	13200	14500	11600	10300	11300	11220	9000	8860
	Delta Cross Cl	7250	8050	6700	5350	6250	6650	5550	5000	5450	5400	4700	4650
	Georgiana Sl	2275	2230	1900	1425	1650	1760	1500	1330	1420	1400	1230	1240
	Ratio	0.46	0.48	0.53	0.63	0.60	0.58	0.61	0.61	0.61	0.61	0.66	0.66
5A	Sacramento R.	20700	20400	16100	10800	13300	15000	11450	10300	11300	11180	9000	8860
	Delta Cross Cl	6150	6450	5500	4350	5100	5500	4500	4100	4450	4400	3800	3800
	Georgiana Sl	2220	2170	1890	1470	1700	1830	1520	1370	1460	1440	1270	1280
	Ratio	0.40	0.42	0.46	0.54	0.51	0.49	0.53	0.53	0.52	0.52	0.56	0.57
Preferred	Sacramento R.	20700	21400	16100	10800	13200	14500	11600	10300	11300	11220	9000	8860
Alternative	Delta Cross Cl	7250	8050	6700	5350	6250	6650	5550	5000	5450	5400	4700	4650
5B	Georgiana Sl	2275	2230	1900	1425	1650	1760	1500	1330	1420	1400	1230	1240
	Ratio	0.46	0.48	0.53	0.63	0.60	0.58	0.61	0.61	0.61	0.61	0.66	0.66
6A	Sacramento R.	20700	20500	16100	10800	13250	14800	11500	10300	11300	11200	9000	8860
	Delta Cross Cl	6550	6850	5850	4550	5350	5750	4750	4300	4650	4650	3850	3950
	Georgiana Sl	2170	2130	1850	1430	1650	1780	1480	1330	1420	1410	1230	1240
	Ratio	0.42	0.44	0.48	0.55	0.53	0.51	0.54	0.55	0.54	0.54	0.56	0.59
6B	Sacramento R.	20700	21600	16100	10800	13200	14500	11600	10300	11300	11200	9000	8860
	Delta Cross Cl	7250	8300	6850	5500	6400	6850	5700	5150	5650	5550	4850	4800
	Georgiana Sl	2350	2300	1950	1450	1680	1800	1540	1360	1440	1420	1250	1260
	Ratio	0.46	0.49	0.55	0.64	0.61	0.60	0.62	0.63	0.63	0.62	0.68	0.68

TABLE C-11 (con't)

RATIO OF DELTA CROSS CHANNEL AND GEORGIANA SLOUGH FLOWS TO SACRAMENTO RIVER FLOW

(MONTHLY AVERAGE FLOWS IN CUBIC FEET PER SECOND)

REPRESENTATIVE DRY YEAR

Alternative		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No-Action	Sacramento R.	12435	22105	15205	21183	16533	16833	15408	13160	13292	17944	10139	10118
	Delta Cross Cl	3599	4943	4142	0	4356	4448	3997	3517	3665	4625	3091	3087
	Georgiana Sl	1799	2540	2045	3152	2155	2173	2032	1808	1818	2222	1561	1575
	Ratio	0.43	0.34	0.41	0.15	0.39	0.39	0.39	0.40	0.41	0.38	0.46	0.46
2A	Sacramento R.	12435	22106	14351	21183	15423	16318	15692	13177	13292	17702	10269	10151
	Delta Cross Cl	4501	6195	4988	0	5205	5432	5068	4398	4548	5706	3884	3883
	Georgiana Sl	1666	2374	1838	3162	1926	1988	1911	1667	1676	2062	1442	1454
	Ratio	0.50	0.39	0.48	0.15	0.46	0.45	0.44	0.46	0.47	0.44	0.52	0.53
2B	Sacramento R.	12400	22100	14100	21200	14820	16320	15820	13180	13300	17750	10850	10100
	Delta Cross Cl	5500	7800	6100	0	6300	6700	6300	5400	5600	7100	4900	4700
	Georgiana Sl	1500	2170	1650	3170	1710	1800	1740	1500	1510	1870	1350	1310
	Ratio	0.56	0.45	0.55	0.15	0.54	0.52	0.51	0.52	0.53	0.51	0.58	0.60
3A	Sacramento R.	12400	22100	14200	21200	15270	16320	15710	13180	13300	17750	10400	10100
	Delta Cross Cl	4700	6600	5300	0	5500	5700	5400	4700	4800	6100	4100	4100
	Georgiana Sl	1630	2330	1790	3170	1870	1940	1870	1620	1630	2010	1420	1420
	Ratio	0.51	0.40	0.50	0.15	0.48	0.47	0.46	0.48	0.48	0.46	0.53	0.55
3B	Sacramento R.	12436	22106	14158	21183	14815	16318	16092	13177	13292	17735	10881	10118
	Delta Cross Cl	5730	7915	6317	0	6513	6946	6601	5600	5789	7301	5143	4940
	Georgiana Sl	1537	2240	1692	3197	1756	1851	1818	1545	1546	1920	1382	1344
	Ratio	0.58	0.46	0.57	0.15	0.56	0.54	0.52	0.54	0.55	0.52	0.60	0.62
4A	Sacramento R.	12400	22100	14200	21200	15220	16320	15730	13180	13300	17750	10450	10100
	Delta Cross Cl	4800	6700	5400	0	5600	5800	5500	4800	4900	6200	4200	4200
	Georgiana Sl	1620	2300	1770	3170	1850	1930	1850	1610	1620	2000	1410	1410
	Ratio	0.52	0.41	0.50	0.15	0.49	0.47	0.47	0.49	0.49	0.46	0.54	0.56
4B	Sacramento R.	12400	22100	14100	21200	14820	16320	16400	13190	13300	17750	10900	10100
	Delta Cross Cl	5900	8000	6600	0	6700	7200	6900	5800	6000	7500	5400	5100
	Georgiana Sl	1570	2320	1740	3240	1800	1900	1900	1590	1580	1970	1420	1380
	Ratio	0.60	0.47	0.59	0.15	0.57	0.56	0.54	0.56	0.57	0.53	0.63	0.64
5A	Sacramento R.	12400	22100	14200	21200	15220	16320	15730	13180	13300	17750	10450	10100
	Delta Cross Cl	4800	6700	5400	0	5600	5800	5500	4800	4900	6200	4200	4200
	Georgiana Sl	1620	2300	1770	3170	1850	1930	1850	1610	1620	2000	1410	1410
	Ratio	0.52	0.41	0.50	0.15	0.49	0.47	0.47	0.49	0.49	0.46	0.54	0.56
Preferred	Sacramento R.	12400	22100	14100	21200	14820	16320	16400	13190	13300	17750	10900	10100
Alternative	Delta Cross Cl	5900	8000	6600	0	6700	7200	6900	5800	6000	7500	5400	5100
5B	Georgiana Sl	1570	2320	1740	3240	1800	1900	1900	1590	1580	1970	1420	1380
	Ratio	0.60	0.47	0.59	0.15	0.57	0.56	0.54	0.56	0.57	0.53	0.63	0.64
6A	Sacramento R.	12400	22100	14150	21200	15100	16320	15750	13180	13300	17750	10600	10100
	Delta Cross Cl	5100	7100	5600	0	5800	6200	5800	5000	5100	6500	4500	4400
	Georgiana Sl	1570	2250	1740	3170	1800	1880	1810	1570	1580	1950	1380	1370
	Ratio	0.54	0.42	0.52	0.15	0.50	0.50	0.48	0.50	0.50	0.48	0.55	0.57
6B	Sacramento R.	12400	22100	14100	21200	14820	16320	16620	13190	13300	17750	11000	10100
	Delta Cross Cl	6100	8100	6700	0	6900	7400	7100	5900	6150	7700	5500	5300
	Georgiana Sl	1600	2380	1780	3270	1840	1940	1970	1630	1620	2010	1460	1410
	Ratio	0.62	0.47	0.60	0.15	0.59	0.57	0.55	0.57	0.58	0.55	0.63	0.66

TABLE C-11 (con't)
RATIO OF DELTA CROSS CHANNEL AND GEORGIANA SLOUGH FLOWS TO SACRAMENTO RIVER FLOW
(MONTHLY AVERAGE FLOWS IN CUBIC FEET PER SECOND)

REPRESENTATIVE BELOW NORMAL YEAR

Alternative		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No-Action	Sacramento R.	17325	16045	19219	18898	19336	22695	15692	12796	14309	19023	16323	11071
	Delta Cross Cl	4054	4238	4335	0	0	0	3946	3487	3897	4803	4330	3300
	Georgiana Sl	2225	2107	2353	2894	2925	3328	2077	1765	1894	2302	2111	1668
	Ratio	0.36	0.40	0.35	0.15	0.15	0.15	0.38	0.41	0.40	0.37	0.39	0.45
2A	Sacramento R.	17326	16513	19220	18898	19336	22695	15126	12797	14309	19008	16372	11071
	Delta Cross Cl	5180	5374	5519	0	0	0	4840	4339	4819	5944	5403	4141
	Georgiana Sl	2070	1990	2194	2901	2933	3335	1878	1625	1751	2147	1973	1543
	Ratio	0.42	0.45	0.40	0.15	0.15	0.15	0.44	0.47	0.46	0.43	0.45	0.51
2B	Sacramento R.	17330	17200	19220	18900	19300	22700	14750	12800	14300	19100	16700	11100
	Delta Cross Cl	6600	6800	7000	0	0	0	5950	5350	5950	7400	6800	5100
	Georgiana Sl	1870	1850	1990	2900	2940	3330	1670	1460	1580	1960	1820	1390
	Ratio	0.49	0.50	0.47	0.15	0.15	0.15	0.52	0.53	0.53	0.49	0.52	0.58
3A	Sacramento R.	17330	16700	19220	18900	19300	22700	15010	12800	14300	19100	16480	11100
	Delta Cross Cl	5500	5700	5900	0	0	0	5100	4600	5100	6300	5800	4400
	Georgiana Sl	2030	1950	2140	2900	2940	3330	1820	1580	1710	2090	1930	1500
	Ratio	0.43	0.46	0.42	0.15	0.15	0.15	0.46	0.48	0.48	0.44	0.47	0.53
3B	Sacramento R.	17327	17530	19219	18898	19336	22695	14826	12813	14309	19040	16742	11071
	Delta Cross Cl	6556	6820	6991	0	0	0	5936	5340	5914	7368	6795	5102
	Georgiana Sl	1955	1924	2076	2931	2966	3353	1734	1504	1616	2002	1875	1440
	Ratio	0.49	0.50	0.47	0.16	0.15	0.15	0.52	0.53	0.53	0.49	0.52	0.59
4A	Sacramento R.	17330	16750	19220	18900	19300	22700	15000	12800	14300	19100	16500	11100
	Delta Cross Cl	5600	5900	6000	0	0	0	5200	4700	5200	6400	5900	4500
	Georgiana Sl	2010	1940	2130	2900	2940	3330	1810	1570	1690	2080	1920	1490
	Ratio	0.44	0.47	0.42	0.15	0.15	0.15	0.47	0.49	0.48	0.44	0.47	0.54
4B	Sacramento R.	17330	17850	19220	18900	19300	22700	14900	12800	14300	19100	16700	11100
	Delta Cross Cl	6700	7400	7100	0	0	0	6200	5700	6400	7800	7300	5600
	Georgiana Sl	2030	2000	2170	2970	3000	3380	1800	1550	1660	2050	1930	1480
	Ratio	0.50	0.53	0.48	0.16	0.16	0.15	0.54	0.57	0.56	0.52	0.55	0.64
5A	Sacramento R.	17330	16750	19220	18900	19300	22700	15000	12800	14300	19100	16500	11100
	Delta Cross Cl	5600	5900	6000	0	0	0	5200	4700	5200	6400	5900	4500
	Georgiana Sl	2010	1940	2130	2900	2940	3330	1810	1570	1690	2080	1920	1490
	Ratio	0.44	0.47	0.42	0.15	0.15	0.15	0.47	0.49	0.48	0.44	0.47	0.54
Preferred	Sacramento R.	17330	17850	19220	18900	19300	22700	14900	12800	14300	19100	16700	11100
Alternative	Delta Cross Cl	6700	7400	7100	0	0	0	6200	5700	6400	7800	7300	5600
5B	Georgiana Sl	2030	2000	2170	2970	3000	3380	1800	1550	1660	2050	1930	1480
	Ratio	0.50	0.53	0.48	0.16	0.16	0.15	0.54	0.57	0.56	0.52	0.55	0.64
6A	Sacramento R.	17330	16900	19220	18900	19300	22700	14900	12800	14300	19100	16600	11100
	Delta Cross Cl	5900	6200	6400	0	0	0	5500	4900	5500	6800	6200	4700
	Georgiana Sl	1960	1910	2080	2900	2940	3330	1750	1530	1650	2030	1880	1460
	Ratio	0.45	0.48	0.44	0.15	0.15	0.15	0.49	0.50	0.50	0.46	0.49	0.55
6B	Sacramento R.	17330	18150	19220	18900	19300	22700	15000	12800	14300	19100	16800	11100
	Delta Cross Cl	6800	7700	7200	0	0	0	6400	5900	6600	8000	7500	5800
	Georgiana Sl	2100	2070	2240	2990	3040	3460	1860	1580	1680	2080	1980	1520
	Ratio	0.51	0.54	0.49	0.16	0.16	0.15	0.55	0.58	0.58	0.53	0.56	0.66

TABLE C-11 (con't)

RATIO OF DELTA CROSS CHANNEL AND GEORGIANA SLOUGH FLOWS TO SACRAMENTO RIVER FLOW

(MONTHLY AVERAGE FLOWS IN CUBIC FEET PER SECOND)

REPRESENTATIVE ABOVE NORMAL YEAR

Alternative		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No-Action	Sacramento R.	16033	18806	18432	16928	50226	67500	22021	34008	22273	19993	19983	14854
	Delta Cross Cl	3767	4534	4383	0	-2	-4	0	6749	4716	4880	4960	3746
	Georgiana Sl	2128	2283	2275	2664	6365	8356	3177	3427	2520	2372	2399	2048
	Ratio	0.37	0.36	0.36	0.16	0.13	0.12	0.14	0.30	0.32	0.36	0.37	0.39
2A	Sacramento R.	16034	19306	18433	16928	50225	67500	22022	34008	22274	19962	19597	14855
	Delta Cross Cl	4847	5757	5516	0	-2	-3	0	8285	5965	6049	6080	4796
	Georgiana Sl	1974	2163	2120	2671	6374	8368	3180	3193	2351	2213	2217	1904
	Ratio	0.43	0.41	0.41	0.16	0.13	0.12	0.14	0.34	0.37	0.41	0.42	0.45
2B	Sacramento R.	16000	20000	18400	16900	50000	67500	22000	34000	22300	19900	19000	14800
	Delta Cross Cl	6200	7400	6900	0	0	0	0	10400	7600	7500	7400	6000
	Georgiana Sl	1780	2020	1930	2680	6380	8360	3200	2880	2130	2020	1980	1720
	Ratio	0.50	0.47	0.48	0.16	0.13	0.12	0.15	0.39	0.44	0.48	0.49	0.52
3A	Sacramento R.	16000	19450	18400	16900	50000	67500	22000	34000	22300	19900	19450	14800
	Delta Cross Cl	5200	6200	5800	0	0	0	0	8800	6400	6400	6400	5100
	Georgiana Sl	1930	2130	2075	2680	6360	8360	3190	3130	2290	2160	2160	1850
	Ratio	0.45	0.43	0.43	0.16	0.13	0.12	0.15	0.35	0.39	0.43	0.44	0.47
3B	Sacramento R.	16034	20322	18432	16927	50225	67500	22022	34008	22274	19961	18711	14855
	Delta Cross Cl	6198	7607	7051	0	-1	-2	0	10346	7609	7735	7567	6127
	Georgiana Sl	1866	2096	1995	2702	6415	8414	3217	2975	2224	2069	2015	1790
	Ratio	0.50	0.48	0.49	0.16	0.13	0.12	0.15	0.39	0.44	0.49	0.51	0.53
4A	Sacramento R.	16000	19500	18400	16900	50000	67500	22000	34000	22300	19900	19400	14800
	Delta Cross Cl	5300	6300	6000	0	0	0	0	9000	6500	6500	6500	5200
	Georgiana Sl	1910	2120	2060	2680	6370	8360	3190	3100	2280	2140	2140	1840
	Ratio	0.45	0.43	0.44	0.16	0.13	0.12	0.15	0.36	0.39	0.43	0.45	0.48
4B	Sacramento R.	16000	20600	18400	16900	50000	67500	22000	34000	22300	19900	18450	14800
	Delta Cross Cl	6200	7800	7200	0	0	0	0	10400	7600	7900	7700	6200
	Georgiana Sl	1950	2180	2070	2730	6450	8460	3230	3080	2320	2130	2050	1860
	Ratio	0.51	0.48	0.50	0.16	0.13	0.13	0.15	0.40	0.44	0.50	0.53	0.54
5A	Sacramento R.	16000	19500	18400	16900	50000	67500	22000	34000	22300	19900	19400	14800
	Delta Cross Cl	5300	6300	6000	0	0	0	0	9000	6500	6500	6500	5200
	Georgiana Sl	1910	2120	2060	2680	6370	8360	3190	3100	2280	2140	2140	1840
	Ratio	0.45	0.43	0.44	0.16	0.13	0.12	0.15	0.36	0.39	0.43	0.45	0.48
Preferred	Sacramento R.	16000	20600	18400	16900	50000	67500	22000	34000	22300	19900	18450	14800
Alternative	Delta Cross Cl	6200	7800	7200	0	0	0	0	10400	7600	7900	7700	6200
5B	Georgiana Sl	1950	2180	2070	2730	6450	8460	3230	3080	2320	2130	2050	1860
	Ratio	0.51	0.48	0.50	0.16	0.13	0.13	0.15	0.40	0.44	0.50	0.53	0.54
6A	Sacramento R.	16000	19700	18400	16900	50000	67500	22000	34000	22300	19900	19300	14800
	Delta Cross Cl	5600	6700	6300	0	0	0	0	9500	6900	6900	6800	5500
	Georgiana Sl	1870	2080	2010	2680	6380	8360	3190	3000	2230	2100	2080	1800
	Ratio	0.47	0.45	0.45	0.16	0.13	0.12	0.15	0.37	0.41	0.45	0.46	0.49
6B	Sacramento R.	16000	20900	18400	16900	50000	67500	22000	34000	22300	19900	18200	14800
	Delta Cross Cl	6300	8000	7300	0	0	0	0	10400	7700	8100	7900	6300
	Georgiana Sl	2020	2260	2130	2760	6500	8500	3280	3180	2380	2180	2080	1920
	Ratio	0.52	0.49	0.51	0.16	0.13	0.13	0.15	0.40	0.45	0.52	0.55	0.56

TABLE C-11 (con't)

RATIO OF DELTA CROSS CHANNEL AND GEORGIANA SLOUGH FLOWS TO SACRAMENTO RIVER FLOW

(MONTHLY AVERAGE FLOWS IN CUBIC FEET PER SECOND)

REPRESENTATIVE WET YEAR

Alternative		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No-Action	Sacramento R.	5418	7959	13576	33877	44797	42517	34890	18493	17698	17298	17062	12551
	Delta Cross Cl	1856	2649	3757	-1	-1	-1	-1	4220	4265	4376	4428	3627
	Georgiana Sl	989	1344	1932	4631	5738	5467	4568	2184	2080	2100	2153	1802
	Ratio	0.53	0.50	0.42	0.14	0.13	0.13	0.13	0.35	0.36	0.37	0.39	0.43
2A	Sacramento R.	5418	7975	13576	33879	44796	42516	34890	18493	17698	17218	16321	12551
	Delta Cross Cl	2280	3280	4743	-1	-1	-1	-1	5287	5268	5382	5343	4541
	Georgiana Sl	877	1214	1799	4596	5739	5475	4576	2032	1932	1945	1951	1674
	Ratio	0.58	0.56	0.48	0.14	0.13	0.13	0.13	0.40	0.41	0.43	0.45	0.50
2B	Sacramento R.	5400	8000	13600	33800	44800	42500	35000	18500	17700	17700	16250	12550
	Delta Cross Cl	2700	3900	5900	0	0	0	0	6600	6500	6800	6600	5600
	Georgiana Sl	770	1090	1640	4580	5740	5480	4590	1850	1750	1800	1775	1520
	Ratio	0.64	0.62	0.55	0.14	0.13	0.13	0.13	0.46	0.47	0.49	0.52	0.57
3A	Sacramento R.	5400	8000	13600	33800	44800	42500	35000	18500	17700	17300	16300	12550
	Delta Cross Cl	2350	3400	5000	0	0	0	0	5600	5600	5700	5700	4800
	Georgiana Sl	880	1190	1770	4600	5740	5480	4590	2000	1880	1910	1910	1630
	Ratio	0.60	0.57	0.50	0.14	0.13	0.13	0.13	0.41	0.42	0.44	0.47	0.51
3B	Sacramento R.	5416	7976	13575	33880	44796	42517	34891	18493	17698	17700	15885	12566
	Delta Cross Cl	2862	4113	6116	-1	-1	-1	-1	6749	6721	7024	6746	5873
	Georgiana Sl	769	1098	1692	4623	5773	5511	4614	1908	1797	1845	1792	1568
	Ratio	0.67	0.65	0.58	0.14	0.13	0.13	0.13	0.47	0.48	0.50	0.54	0.59
4A	Sacramento R.	5400	8000	13600	33800	44800	42500	35000	18500	17700	17400	16300	12550
	Delta Cross Cl	2400	3500	5100	0	0	0	0	5700	5700	5850	5800	4900
	Georgiana Sl	850	1160	1750	4590	5740	5480	4590	1980	1870	1890	1890	1620
	Ratio	0.60	0.58	0.50	0.14	0.13	0.13	0.13	0.42	0.43	0.44	0.47	0.52
4B	Sacramento R.	5400	8000	13600	33800	44800	42500	35000	18500	17700	17700	15500	12600
	Delta Cross Cl	3000	4300	6300	0	0	0	0	6800	6900	7250	6900	6100
	Georgiana Sl	750	1110	1740	4690	5790	5550	4660	1990	1850	1890	1810	1620
	Ratio	0.69	0.68	0.59	0.14	0.13	0.13	0.13	0.48	0.49	0.52	0.56	0.61
5A	Sacramento R.	5400	8000	13600	33800	44800	42500	35000	18500	17700	17400	16300	12550
	Delta Cross Cl	2400	3500	5100	0	0	0	0	5700	5700	5850	5800	4900
	Georgiana Sl	850	1160	1750	4590	5740	5480	4590	1980	1870	1890	1890	1620
	Ratio	0.60	0.58	0.50	0.14	0.13	0.13	0.13	0.42	0.43	0.44	0.47	0.52
Preferred	Sacramento R.	5400	8000	13600	33800	44800	42500	35000	18500	17700	17700	15500	12600
Alternative	Delta Cross Cl	3000	4300	6300	0	0	0	0	6800	6900	7250	6900	6100
5B	Georgiana Sl	750	1110	1740	4690	5790	5550	4660	1990	1850	1890	1810	1620
	Ratio	0.69	0.68	0.59	0.14	0.13	0.13	0.13	0.48	0.49	0.52	0.56	0.61
6A	Sacramento R.	5400	8000	13600	33800	44800	42500	35000	18500	17700	17500	16300	12550
	Delta Cross Cl	2500	3600	5400	0	0	0	0	6000	6000	6200	6050	5150
	Georgiana Sl	820	1140	1700	4580	5740	5480	4590	1920	1830	1860	1850	1590
	Ratio	0.61	0.59	0.52	0.14	0.13	0.13	0.13	0.43	0.44	0.46	0.48	0.54
6B	Sacramento R.	5400	8000	13600	33800	44800	42500	35000	18500	17700	17700	15100	12600
	Delta Cross Cl	3200	4500	6500	0	0	0	0	6900	7100	7400	7000	6300
	Georgiana Sl	750	1120	1800	4710	5810	5580	4690	2040	1890	1930	1830	1660
	Ratio	0.73	0.70	0.61	0.14	0.13	0.13	0.13	0.48	0.51	0.53	0.58	0.63

Table C-12. Impacts on February 1986 Flood Stages (1)

Location	Recorded Feb. 86 Stages	DWOPER/NETWORK Model Simulation Results					
		Actual Levee Brks(2)		Mc Cormack-W. and Glanville Levee Breaks			
		No Action Alternative		No Action Alternative		Preferred Alternative	
		Current Lambert	Proposed Lambert	Current Lambert	Proposed Lambert	Current Lambert	Proposed Lambert
Mokelumne-South Fork							
Benson's Ferry	18.3	17.7	18.1	17.8	18.1	13.5	13.5
New Hope Landing	13.1(3)	12.1	13.3	12.2	13.3	8.9	8.9
Hog Slough	-	7.2	7.2	7.2	7.2	7.1	7.1
Terminous	-	7.0	7.1	7.1	7.1	7.0	7.0
Jct., North Fork	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Snodgrass-North Fork							
Lambert Rd, north	14.1	13.5	12.8	13.7	12.8	10.2	10.2
Lambert Rd, south	14.1	13.7	15.1	13.8	15.1	10.5	10.5
Twin Cities Rd	14.2	13.7	15.1	13.8	15.1	10.5	10.5
Delta Cross Channel	13.9	12.6	13.8	12.6	13.8	9.3	9.3
Jct., North Fork	12.0(4)	12.0	13.1	12.0	13.1	8.7	8.7
Mid-Staten Is.	-	7.6	7.8	8.0	8.1	7.2	7.2
Jct., South Fork	7.0	7.0	7.0	7.0	7.0	7.0	7.0

(1) Note: Stages are referenced to 0.0' NGVD. Stages are approximate and presented for comparison purposes only

(2) Levee Breaks on Mc Cormack-Williamson Tract, Glanville Tract, Dead Horse Island, Tyler Island, and New Hope Tract

(3) High water mark upstream from Walnut Grove-Thornton Road Bridge

(4) High water mark 100 feet upstream from Giusti's Restaurant

Table C-13. Preferred Alternative(5B) Impacts on 100-Year Flood Stages (1)

Location	Levee Break Scenario 1				Levee Break Scenario 2			
	No Action Alternative(2)		Preferred Alternative(3)		No Action Alternative(2)		Preferred Alternative(3)	
	Current Lambert	Proposed Lambert	Current Lambert	Proposed Lambert	Current Lambert	Proposed Lambert	Current Lambert	Proposed Lambert
Mokelumne-South Fork								
Benson's Ferry	18.9	19.8	14.8	14.8	18.5	19.1	14.6	14.6
New Hope Landing	14.0	15.5	10.8	11.0	13.4	14.8	10.5	10.6
Hog Slough	8.3	8.6	8.6	8.6	8.2	8.4	8.5	8.5
Terminous	8.0	8.0	8.0	8.0	7.9	8.0	8.0	8.0
Jct. North Fork	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
Snodgrass-North Fork								
Lambert Rd, north	13.9	11.5	11.0	10.7	13.4	11.4	10.8	10.6
Lambert Rd, south	15.4	17.2	12.0	12.3	14.8	16.4	11.7	11.9
Twin Cities Rd	15.4	17.2	12.0	12.3	14.8	16.4	11.7	11.9
Delta Cross Channel	14.4	16.0	11.2	11.4	13.9	15.2	10.9	11.0
Jct., North Fork	13.9	15.3	10.5	10.7	13.3	14.6	10.3	10.4
Mid-Staten Is.	9.3	9.9	8.7	8.8	9.2	9.6	8.6	8.6
Jct., South Fork	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7

Levee Break Scenario 1: McCormack Williamson Tract floods

Levee Break Scenario 2: McCormack Williamson Tract and Glanville Tract flood

(1) Note: Stages are referenced to 0.0' NGVD. Stages are approximate and presented for comparison purposes only

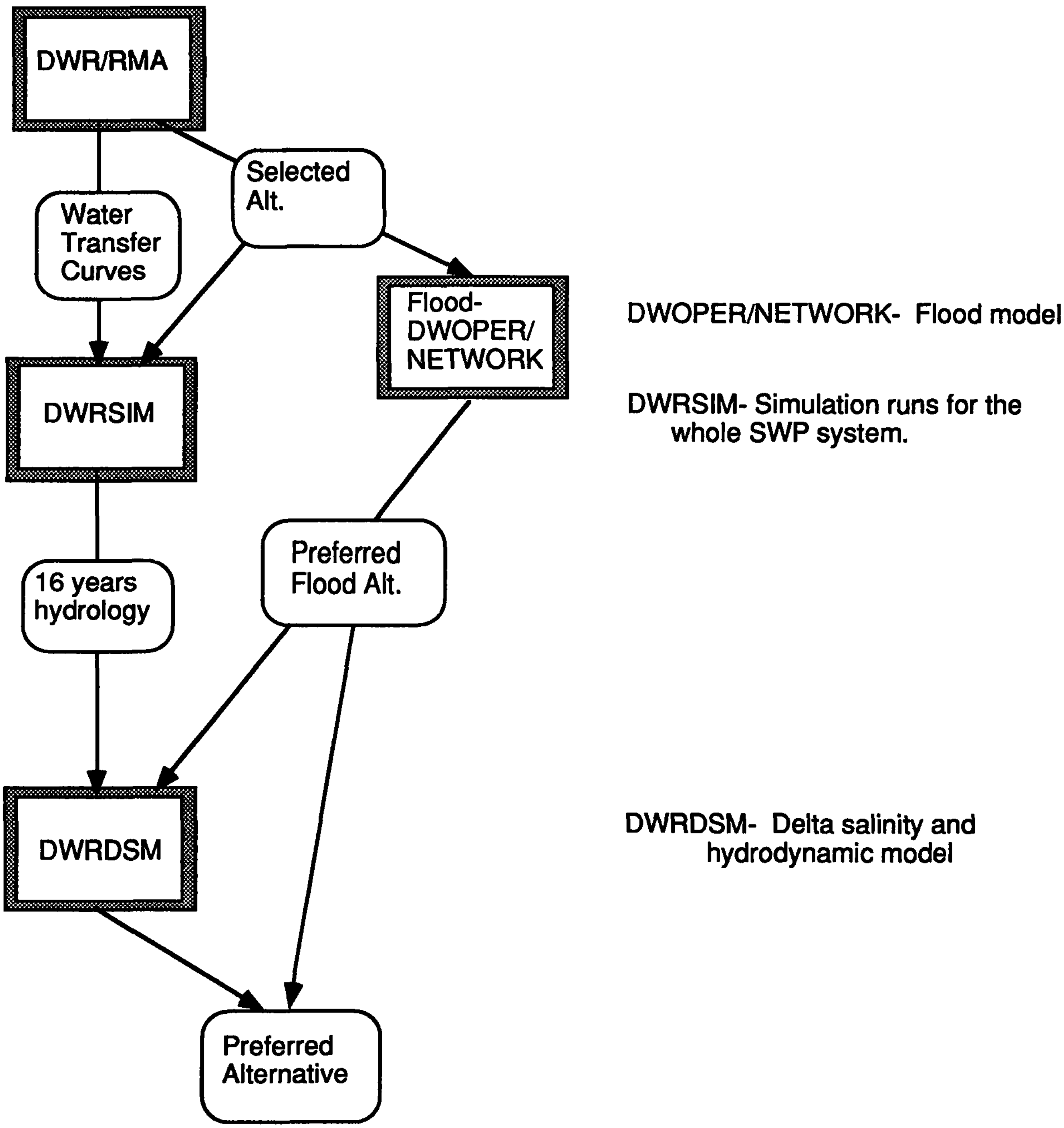
(2) The current level of development in the Morrison Creek Stream Group basin is assumed. With ultimate development in the basin, add about 0.3 feet to stages upstream of Lambert Road, 0.2 feet to stages between Lambert Road and New Hope Landing, and 0.1 feet to the stage at Benson's Ferry.

(3) Impacts of development in the Morrison Creek Stream Group basin would be less than noted in (2), above.

Table C-14
FLOOD STATISTICS

STREAM	FEB 86		100 -year	
	Peak Flow (cfs)	7 - day Volume (acre.ft)	Peak Flow (cfs)	7 - day Volume (acre.ft)
Morrison Creek Stream Group	13768	17	9023	11
Consumnes R.	51653	314509	70606	323691
Mokelumne & Dry Creek	32545	178604	28222	208678

FIGURE C-1
NDP MODELING PROCESS



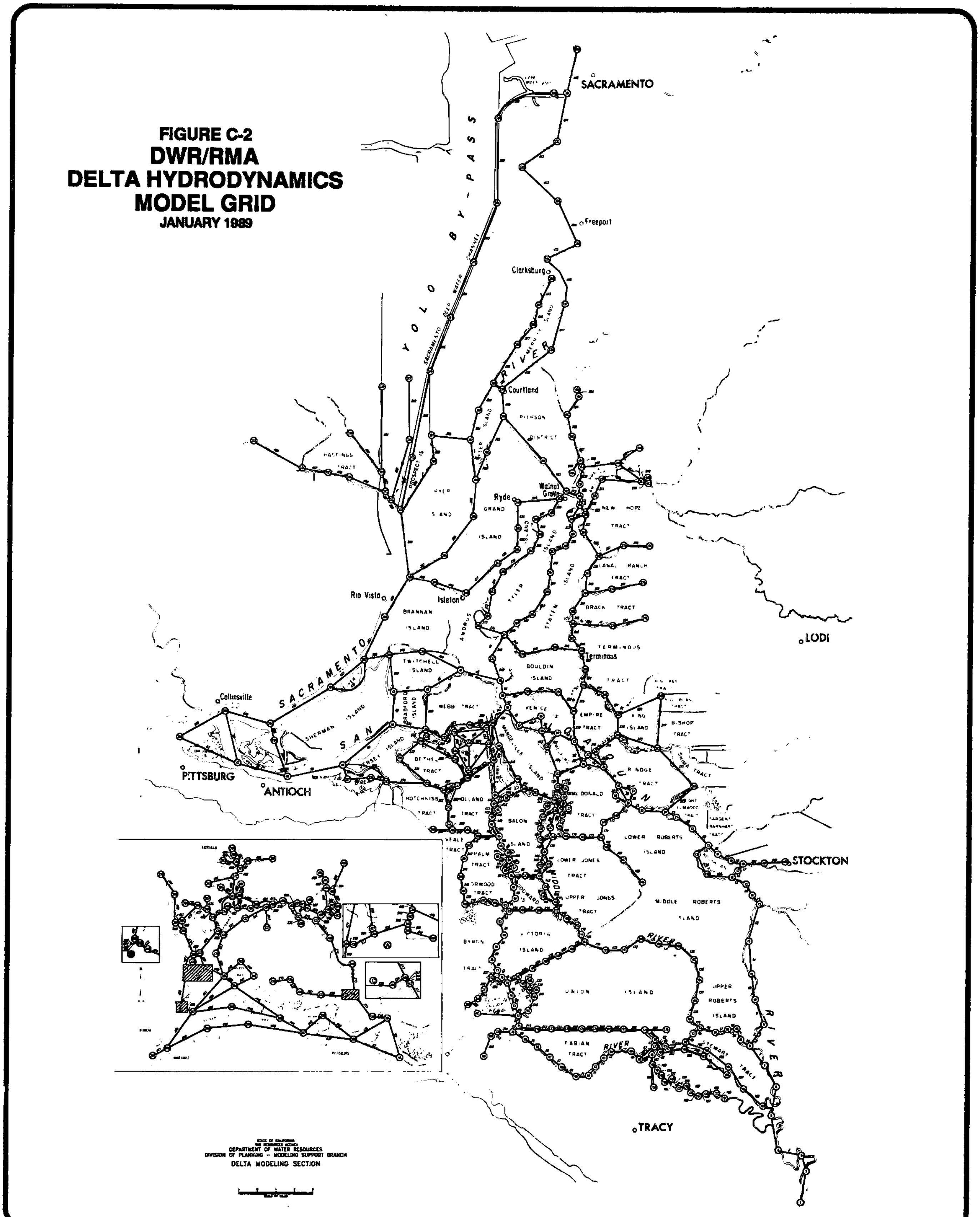


FIGURE C-2
DWR/RMA
DELTA HYDRODYNAMICS
MODEL GRID
JANUARY 1989
SACRAMENTO
Freeport
Clarksburg
YOLO BY-PASS
SACRAMENTO DEEP WATER CHANNEL
RIVER
Courtland
Walnut Grove
Ryde
Rio Vista
Isleton
LODI
Terminous
Collinsville
SACRAMENTO
SAN
PITTSBURG
ANTIOCH
STOCKTON
TRACY
DELTA MODELING SECTION

FIGURE C-3

DWR DELTA SIMULATION MODEL GRID

FRBRUARY 1990

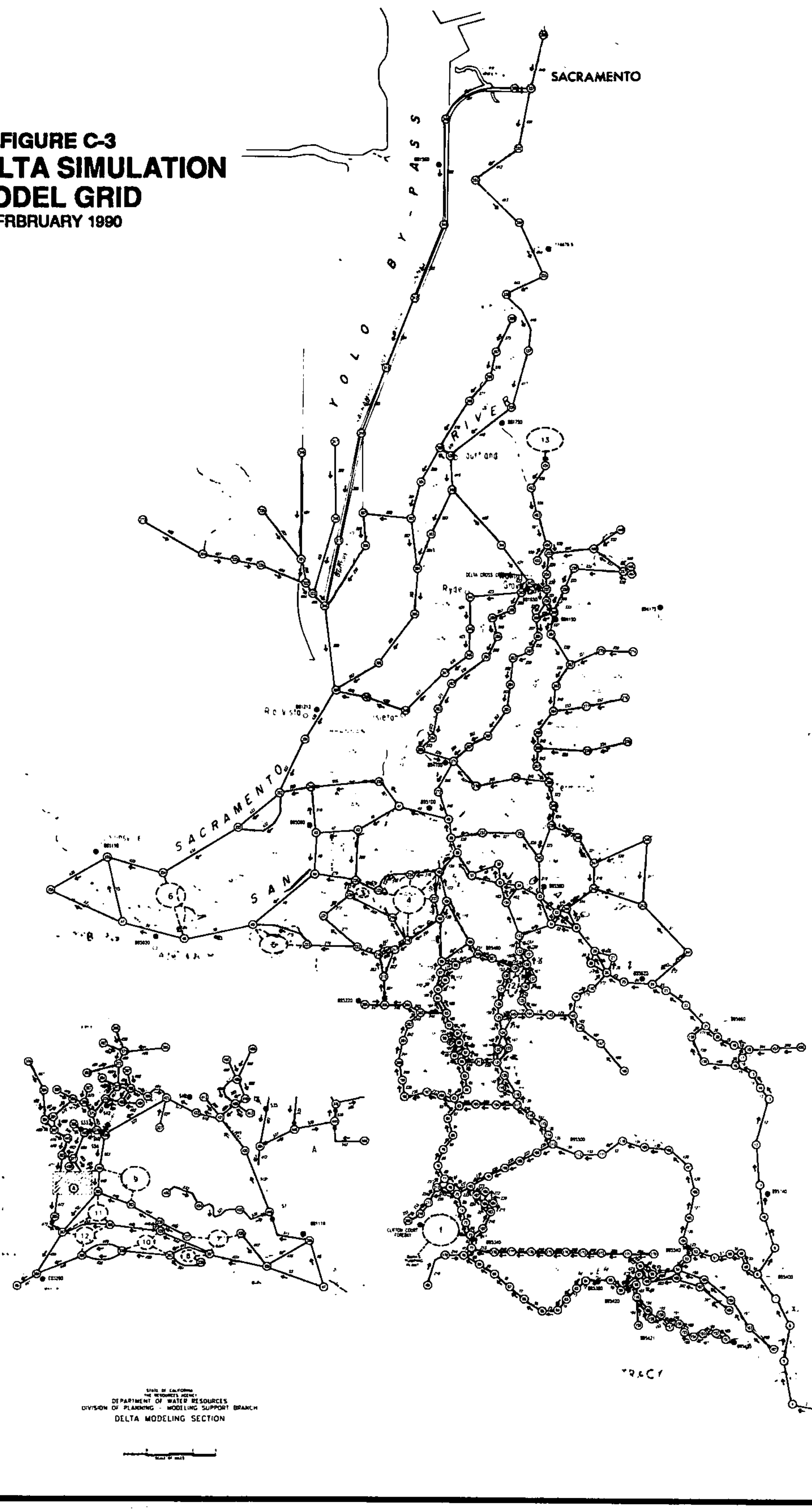


FIGURE C-4
PHASE I MODELING

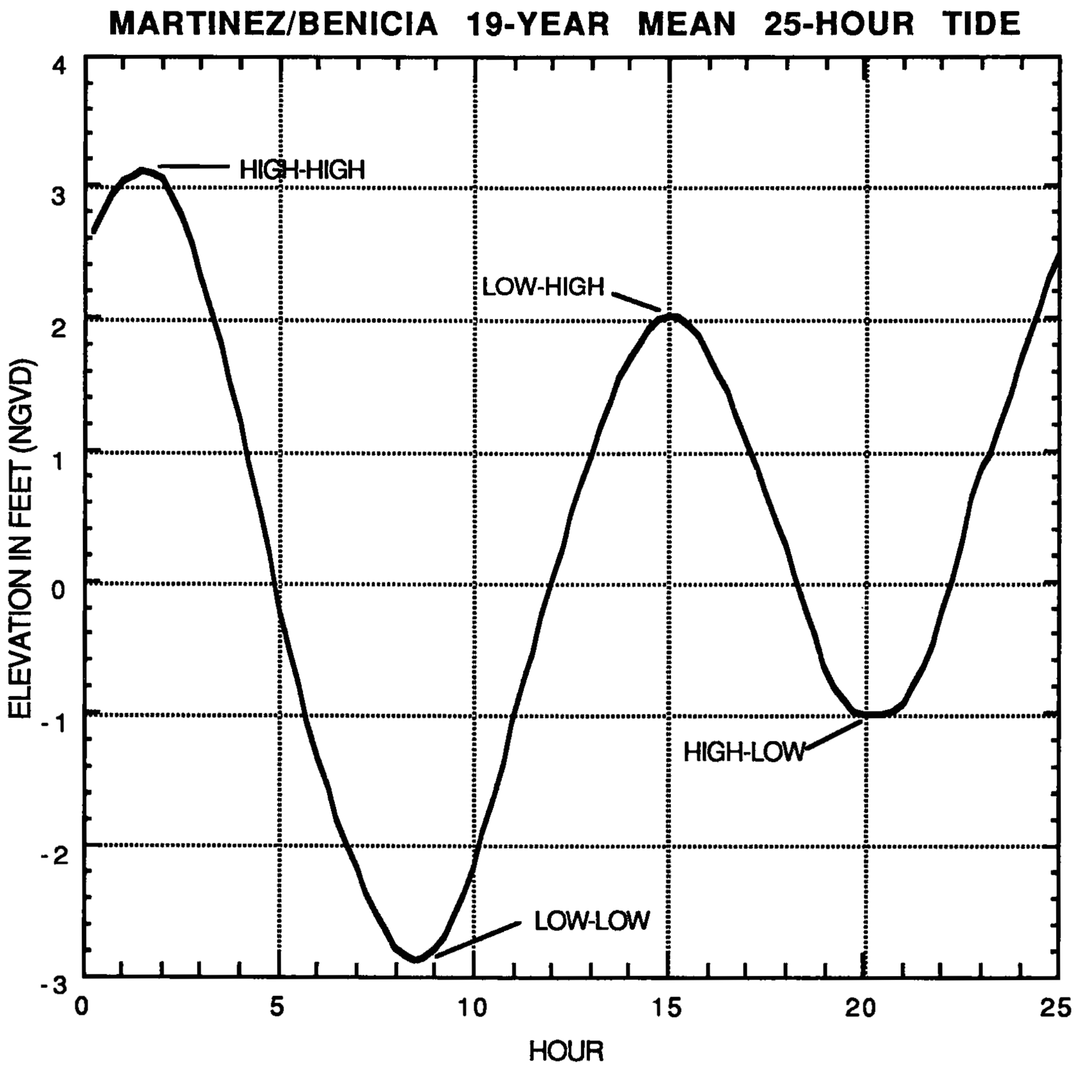
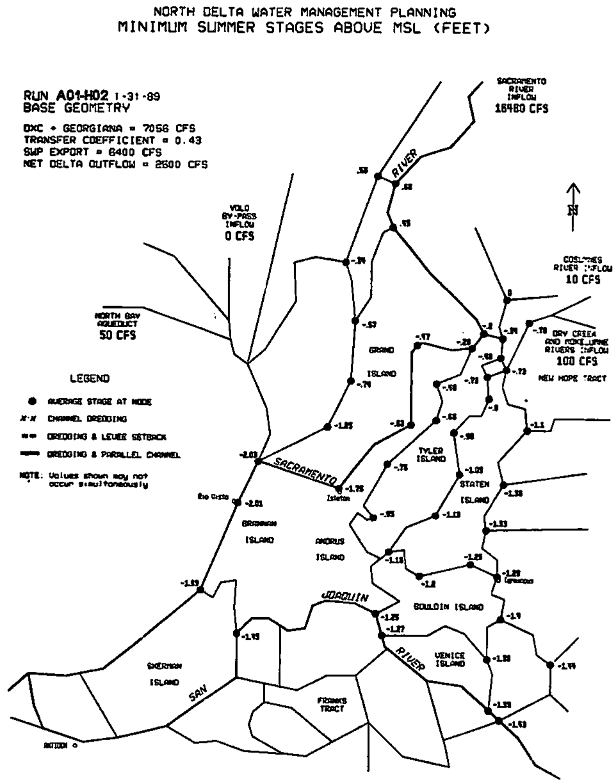


FIGURE C-5
PHASE I DELTA MODELING

SAMPLE MINIMUM STAGE AND DELTA FLOW SCHEMATICS



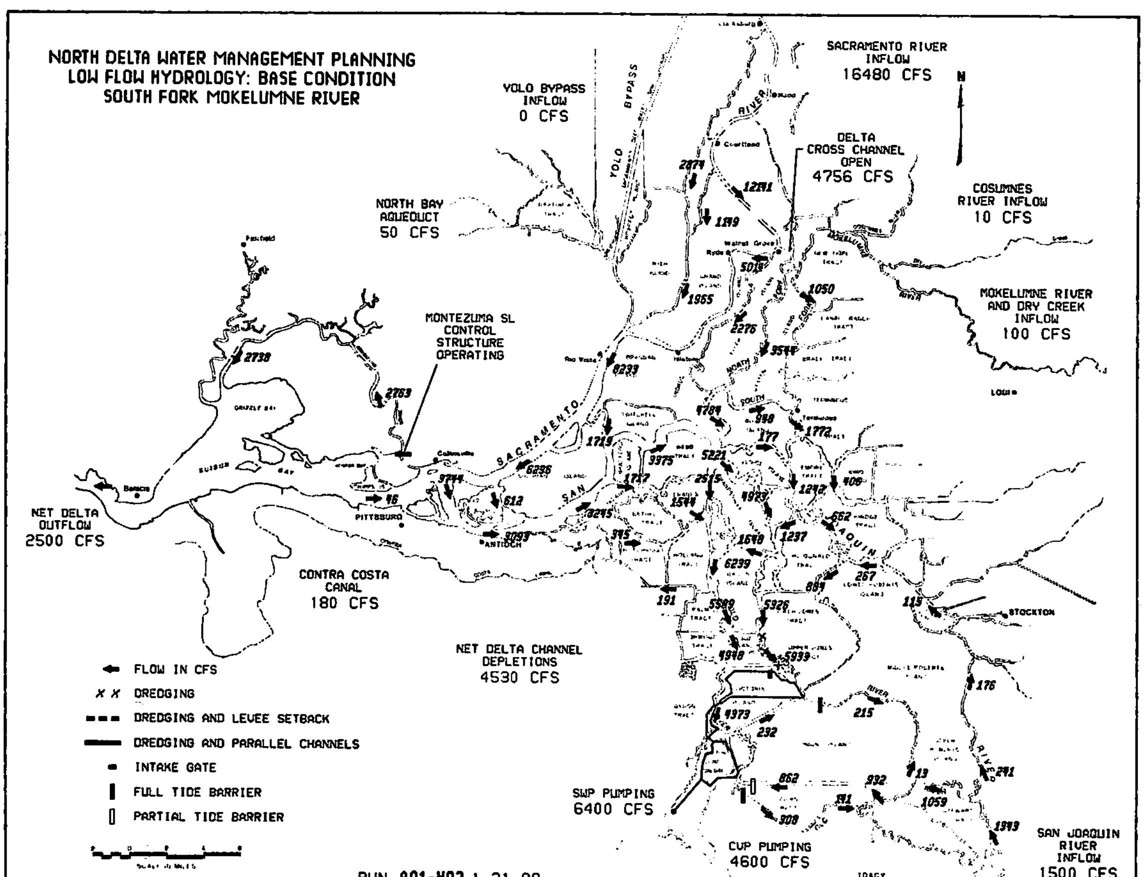
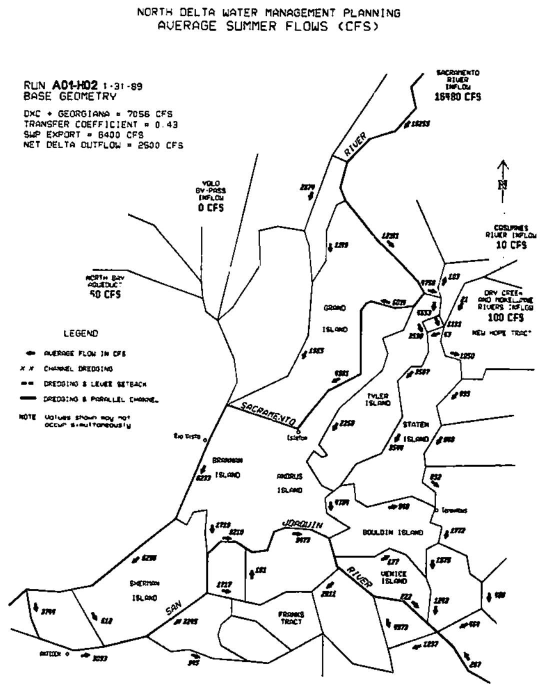
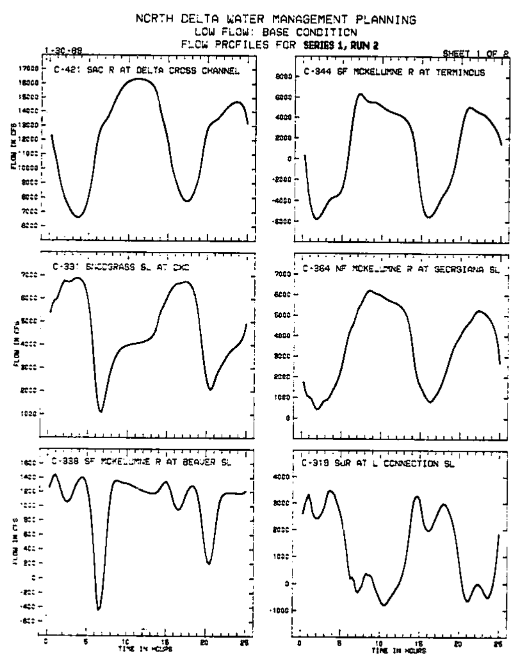


FIGURE C-6
PHASE I DELTA MODELING

SAMPLE FLOW SCHEMATIC AND PROFILES





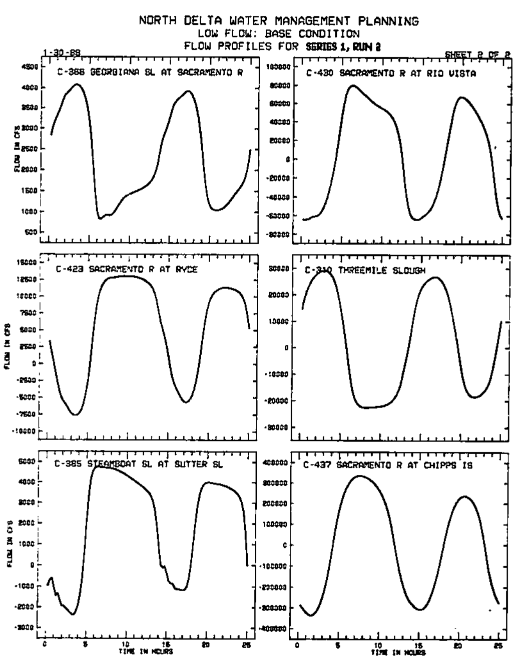


FIGURE C-7
PHASE I DELTA MODELING
SAMPLE VELOCITY SCHEMATICS AND PROFILES

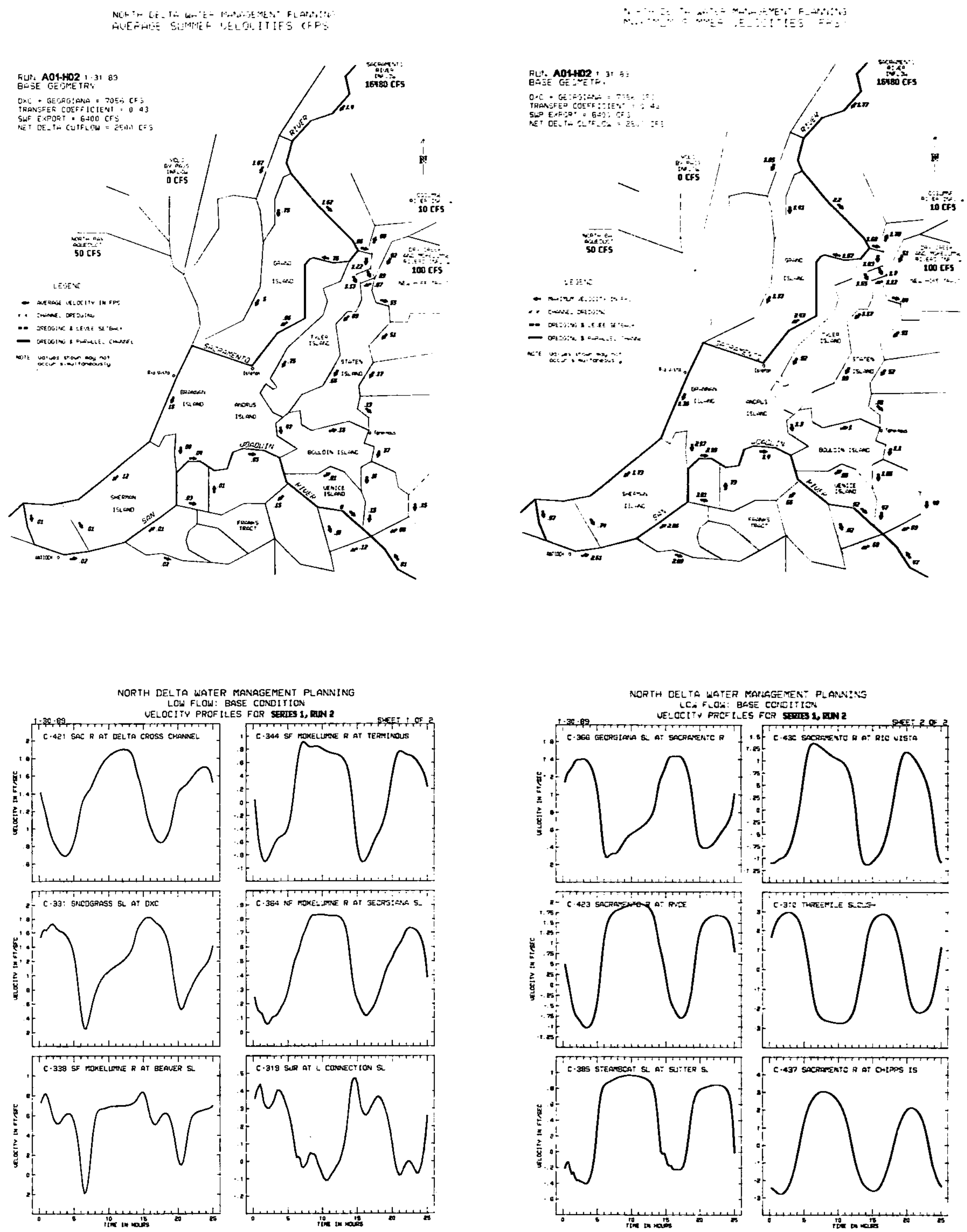
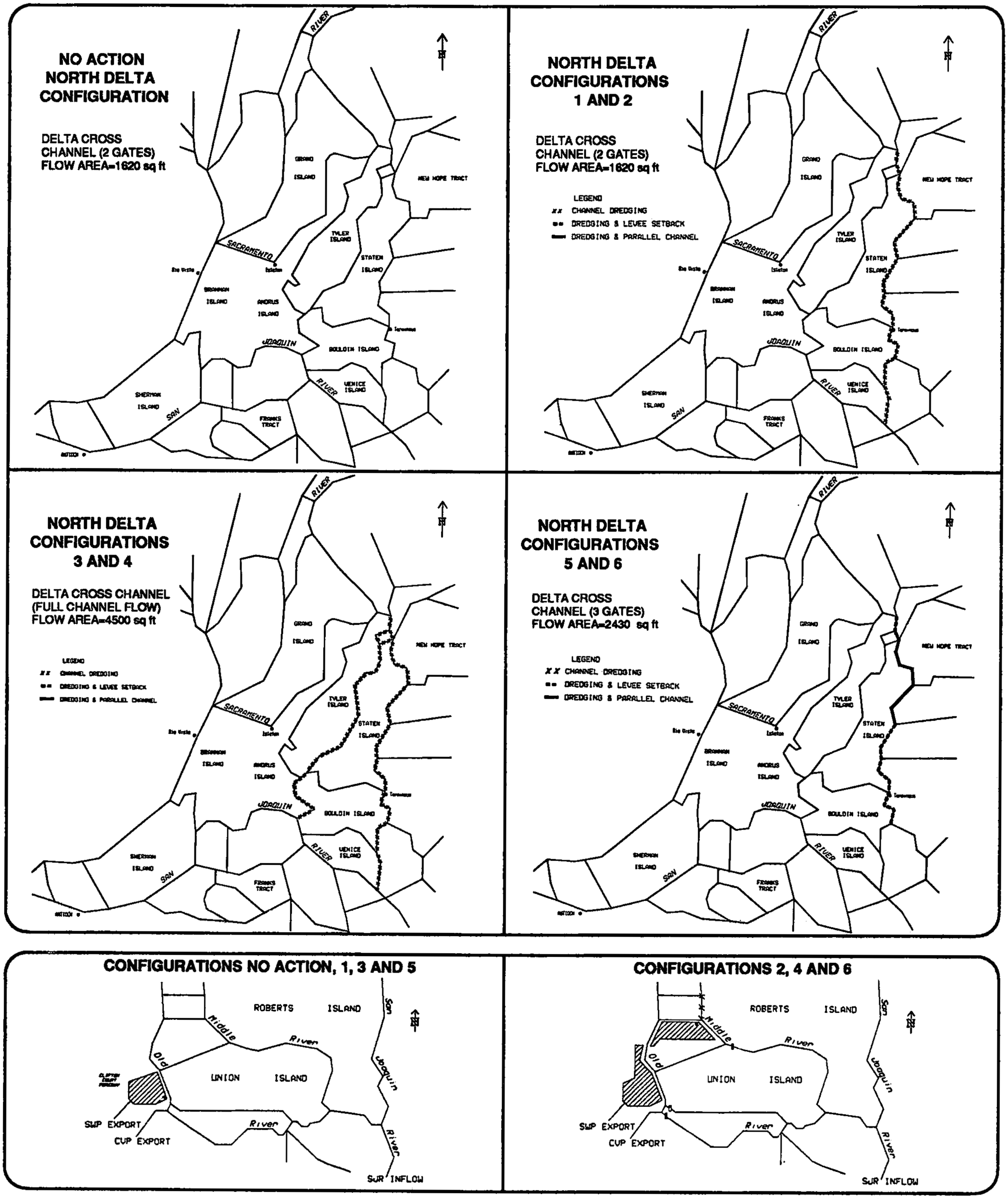


FIGURE C-8
PHASE II DELTA MODELING
ALTERNATIVE NORTH DELTA CONFIGURATIONS



North Delta EIR: WY September 1964 Base Case: DWRSIM 2000-BASE-423D

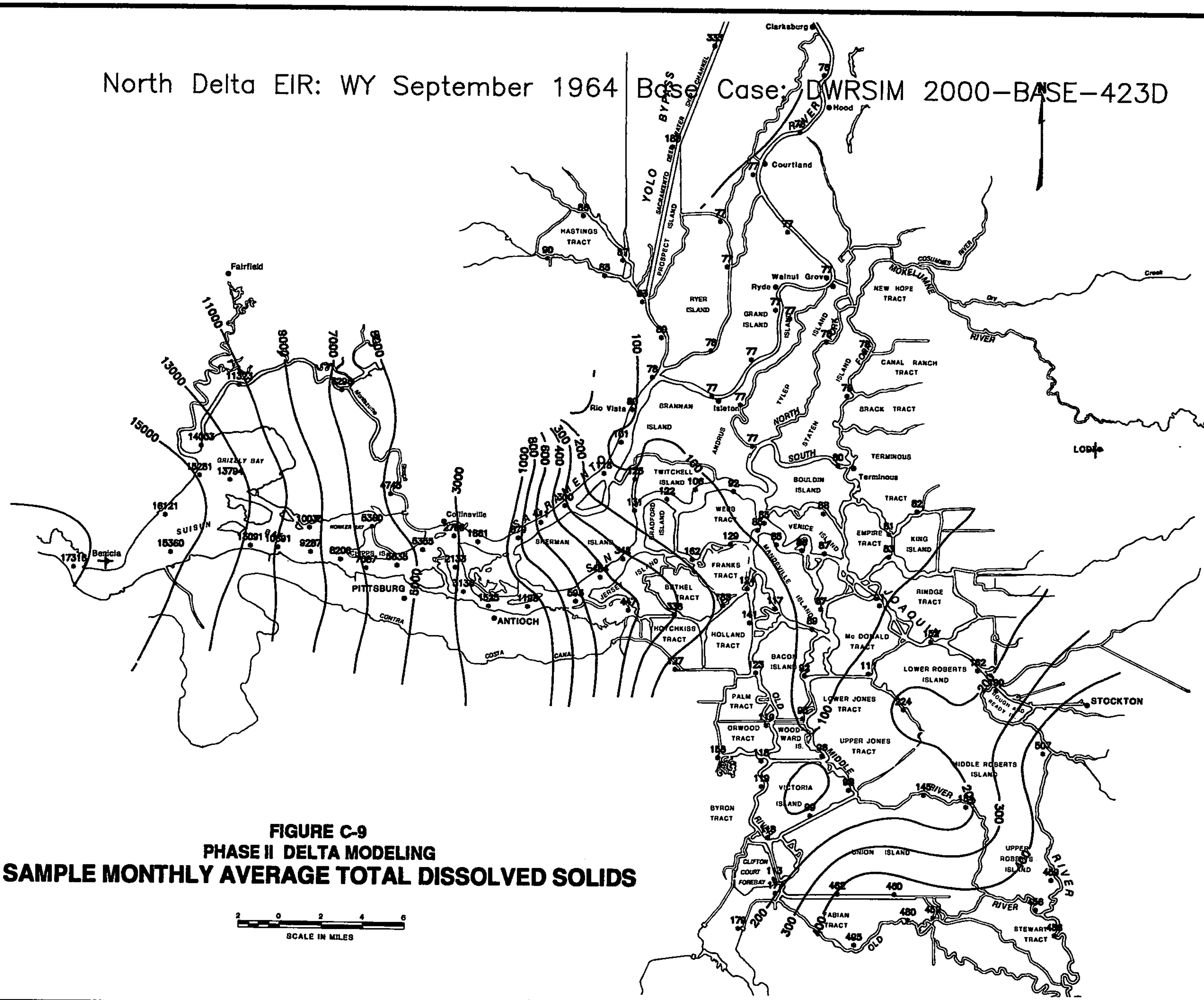


FIGURE C-9
PHASE II DELTA MODELING
SAMPLE MONTHLY AVERAGE TOTAL DISSOLVED SOLIDS

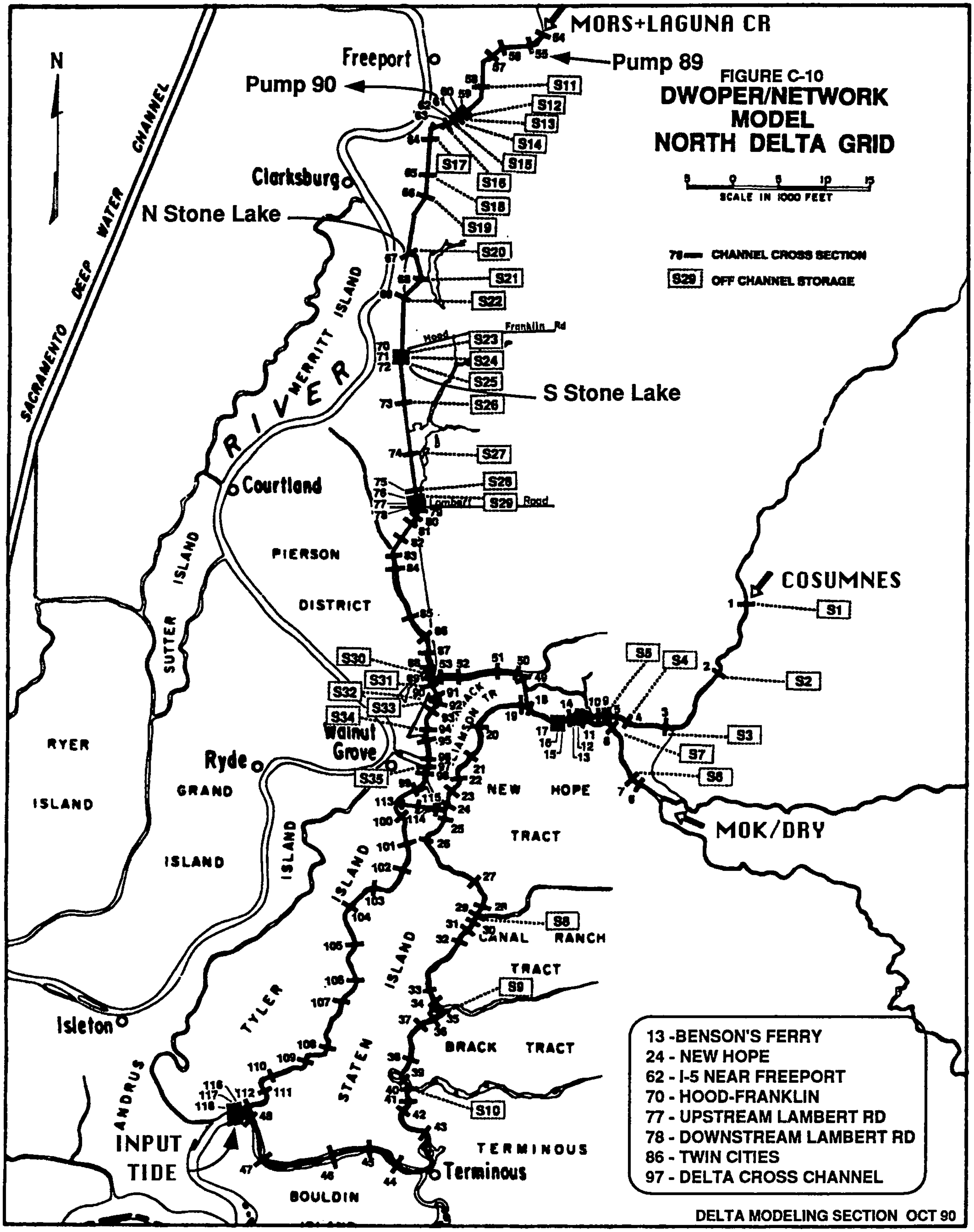


FIGURE C-10
DWOPER/NETWORK
MODEL
NORTH DELTA GRID
SCALE IN 1000 FEET
CHANNEL CROSS SECTION
OFF CHANNEL STORAGE
MORS+LAGUNA CR
Pump 89
Pump 90
Freeport
Clarksburg
N Stone Lake
S Stone Lake
COSUMNES
MOK/DRY
INPUT
TIDE
Courtland
Walnut
Grove
Ryde
Isleton
Terminous
13 -BENSON'S FERRY
24 - NEW HOPE
62 - I-5 NEAR FREEPORT
70 - HOOD-FRANKLIN
77 - UPSTREAM LAMBERT RD
78 - DOWNSTREAM LAMBERT RD
86 - TWIN CITIES
97 - DELTA CROSS CHANNEL
DELTA MODELING SECTION OCT 90

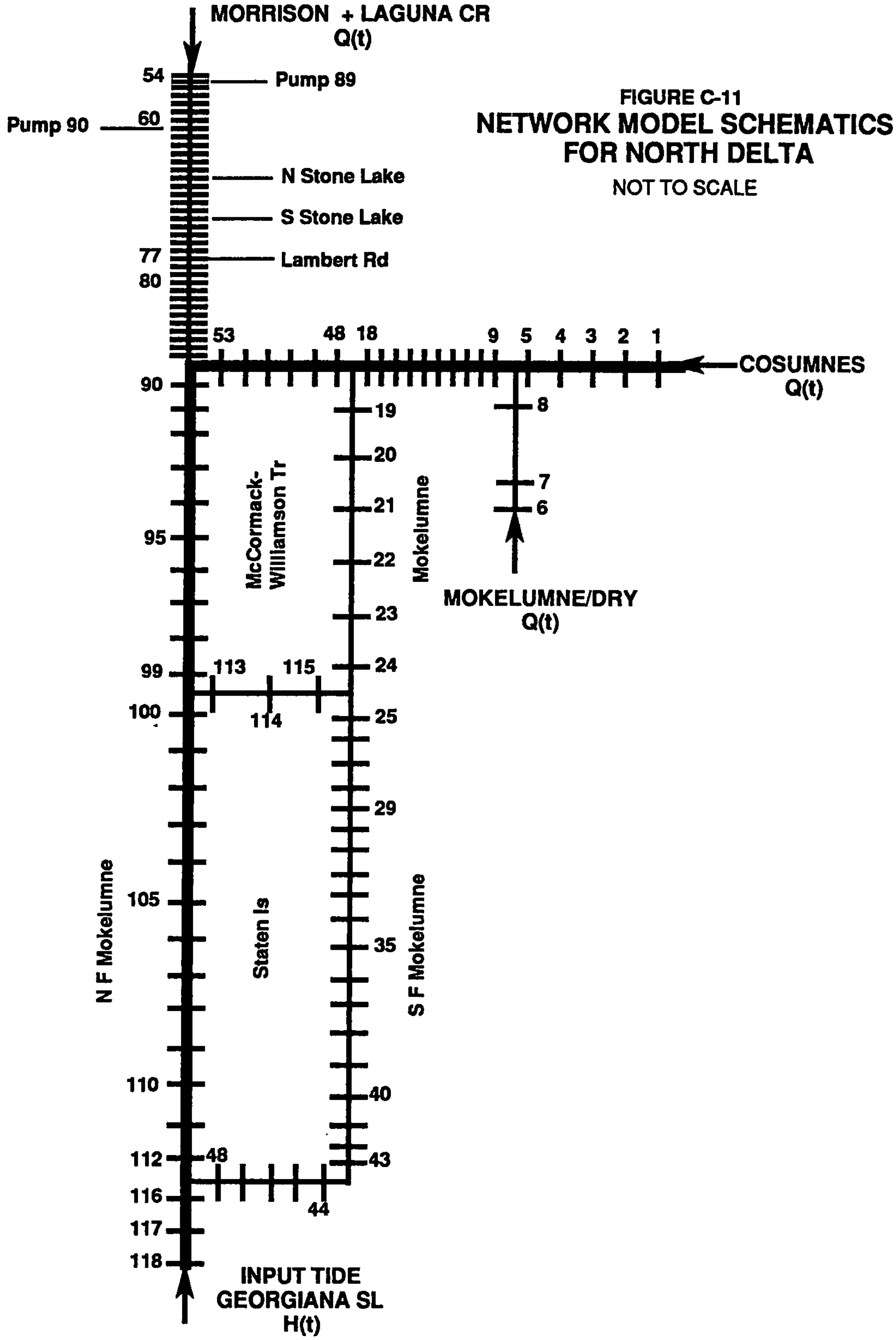
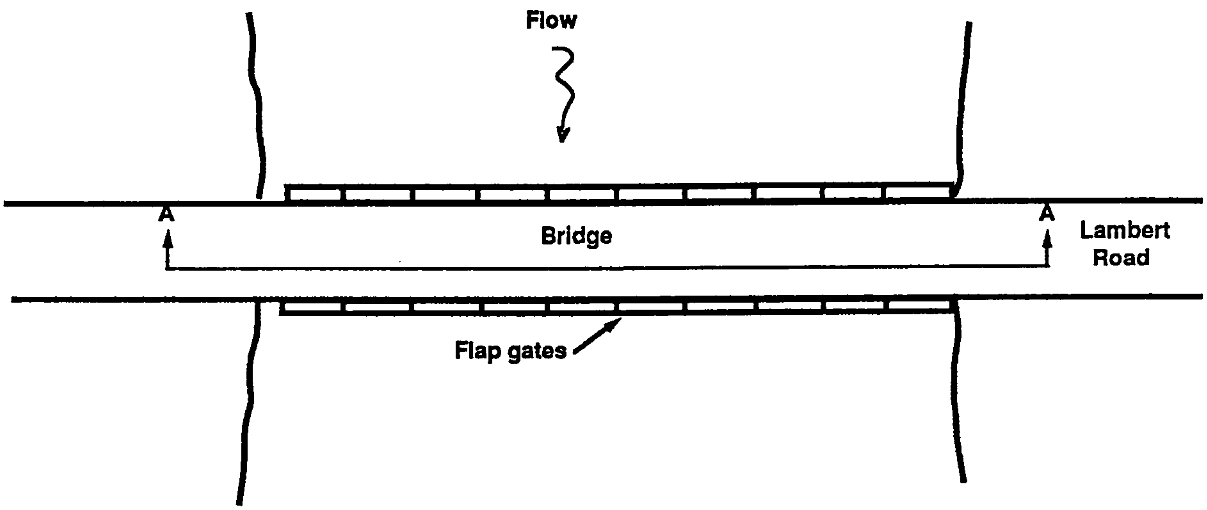


FIGURE C-11
NETWORK MODEL SCHEMATICS
FOR NORTH DELTA
NOT TO SCALE

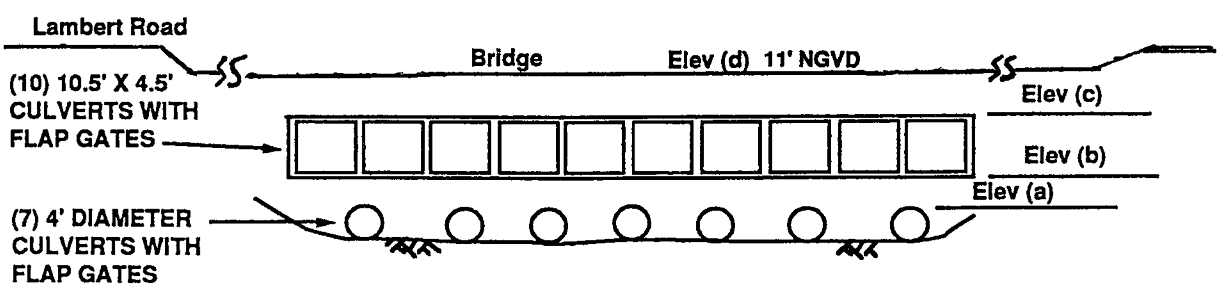
DELTA MODELING SECTION OCT 90

FIGURE C-12

LAMBERT ROAD HYDRAULIC STRUCTURE



PLAN VIEW
NOT TO SCALE



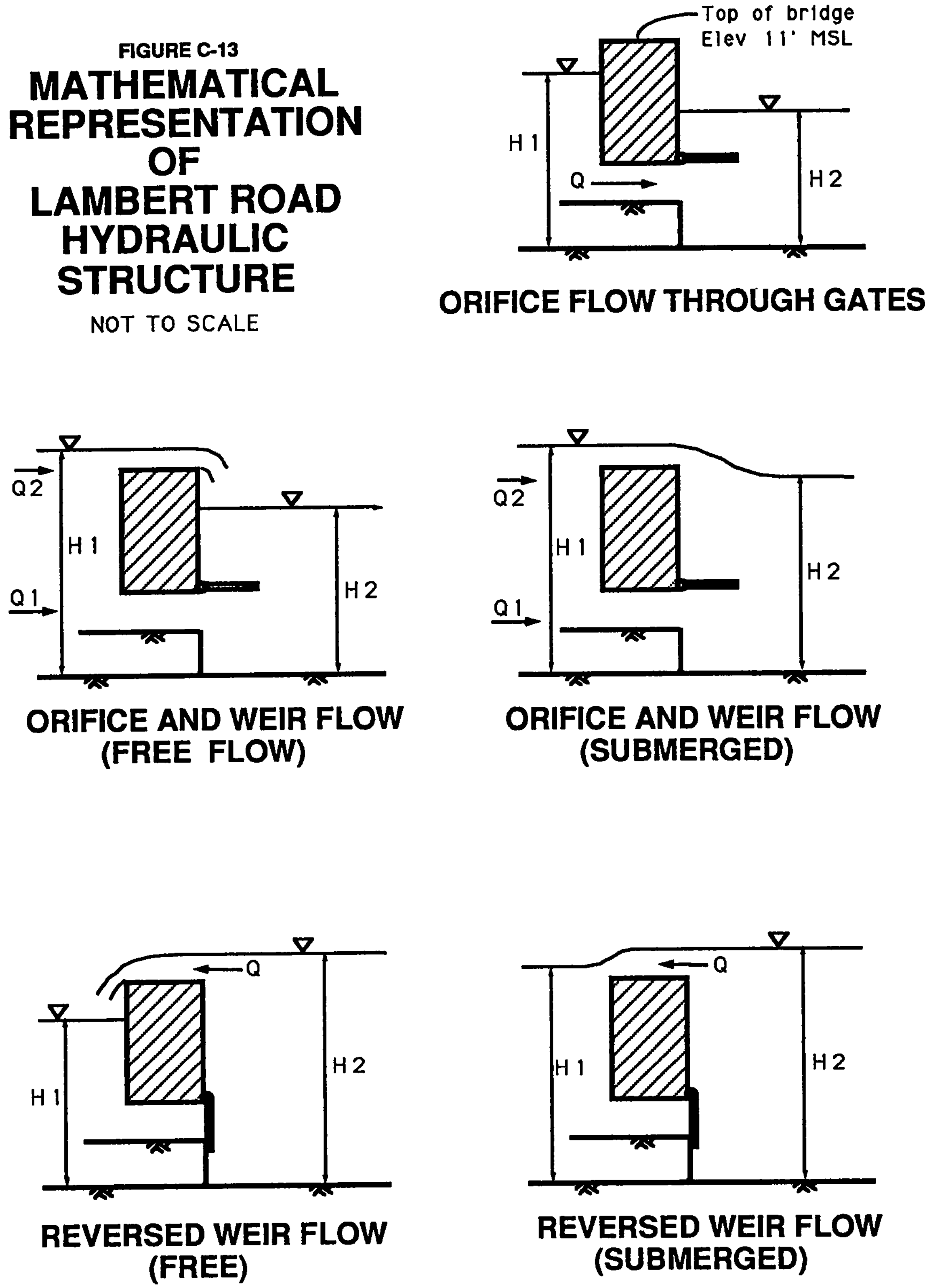
SECTION A - A
NOT TO SCALE

DELTA MODELING SECTION OCT 90

FIGURE C-13

MATHEMATICAL REPRESENTATION OF LAMBERT ROAD HYDRAULIC STRUCTURE

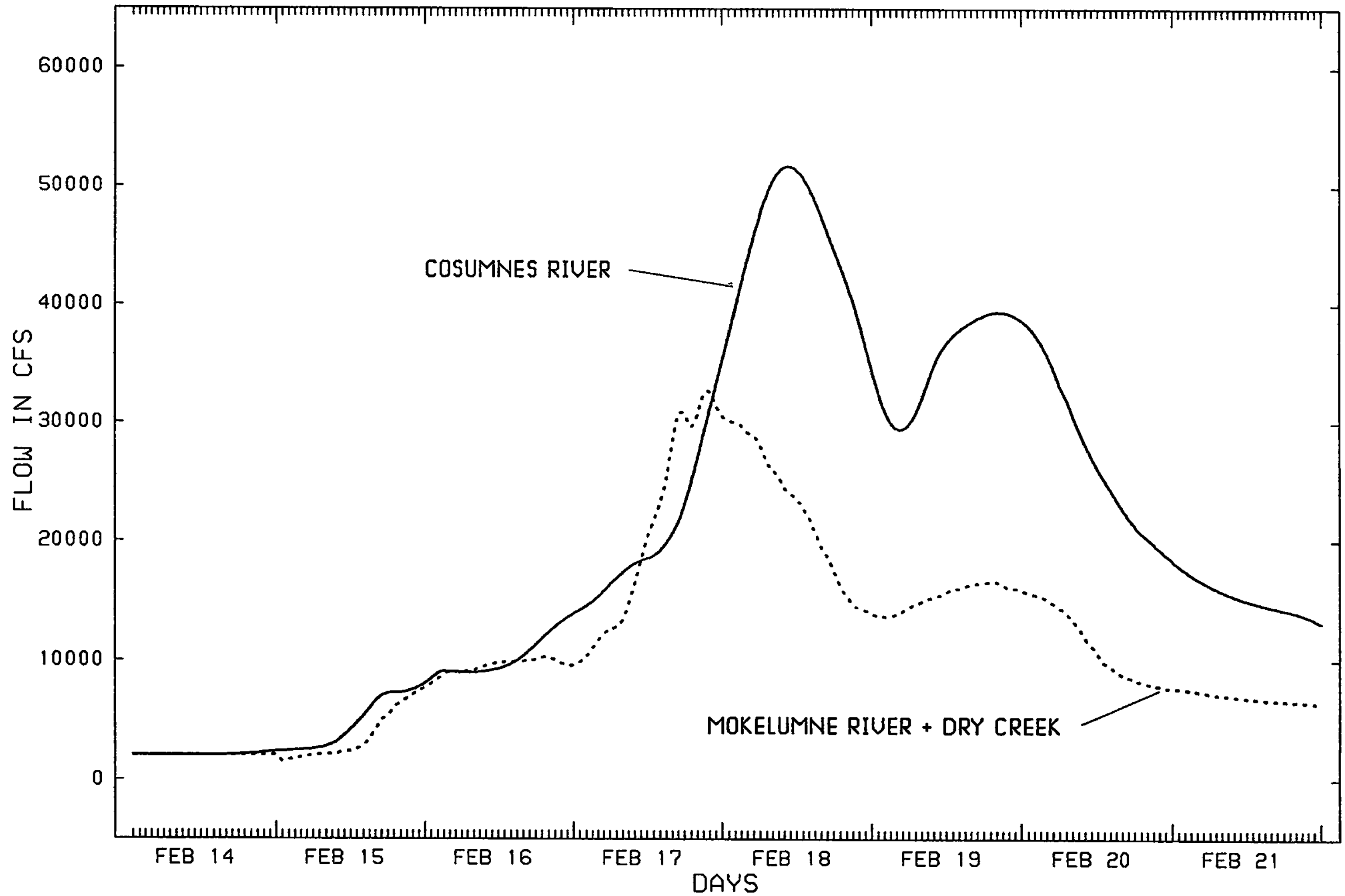
NOT TO SCALE



DELTA MODELING SECTION OCT 90

FIGURE C-14

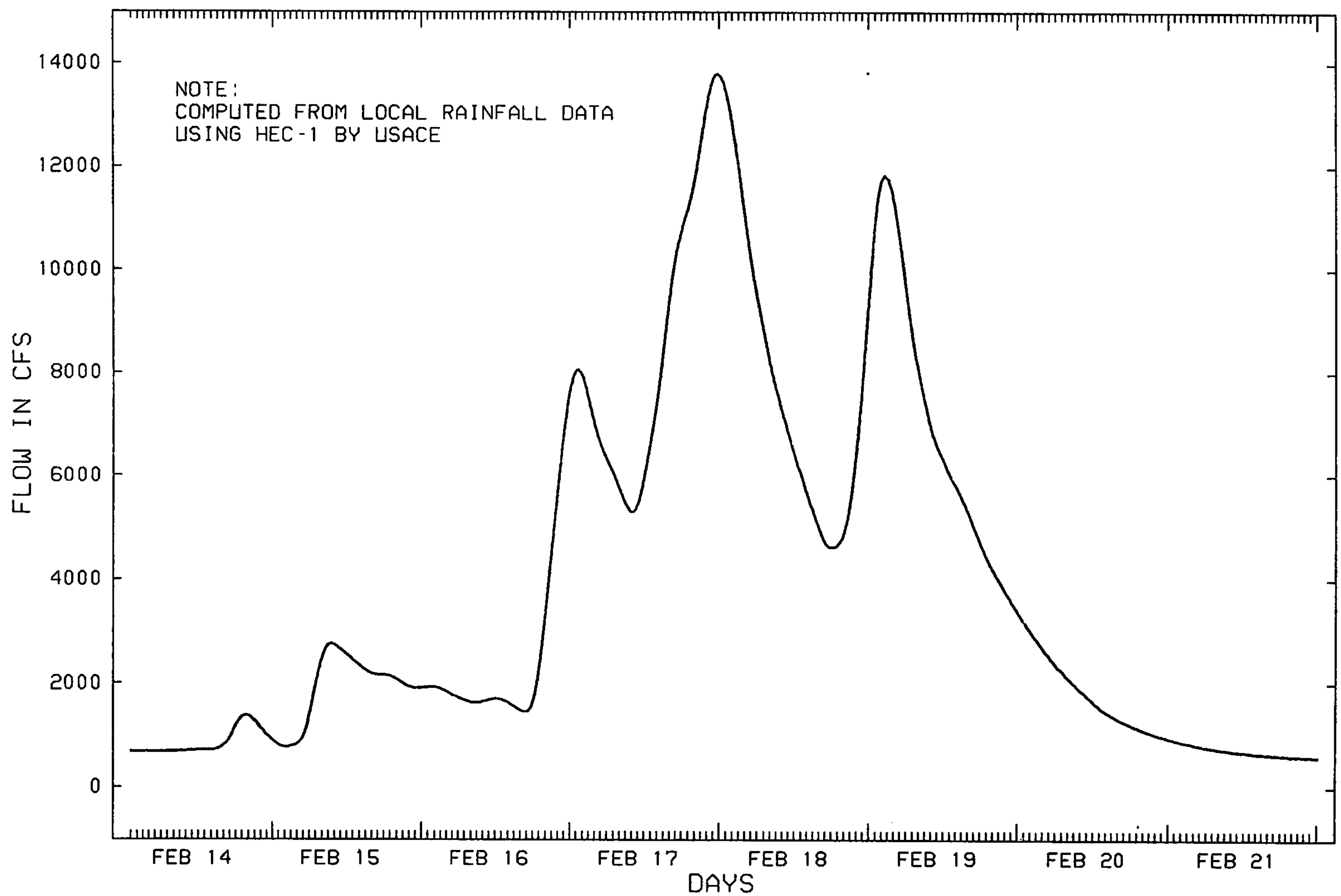
1986 FLOOD
INFLOW HYDROGRAPHS
MOKELUMNE RIVER AND TRIBUTARIES



DELTA MODELING SECTION OCT 90

FIGURE C-15

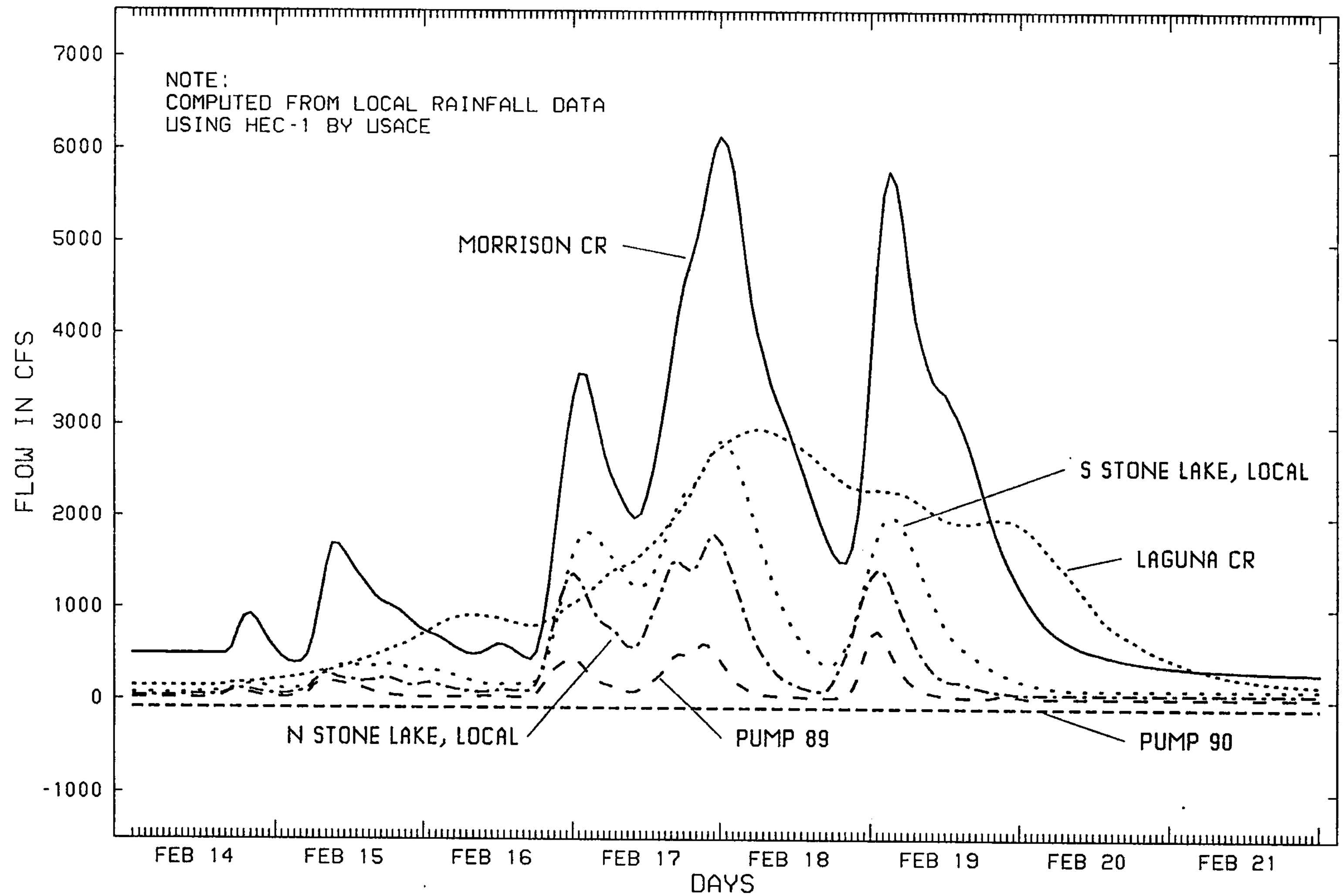
1986 FLOOD
COMBINED INFLOW HYDROGRAPHS
MORRISON STREAM GROUP



DELTA MODELING SECTION OCT 90

FIGURE C-16

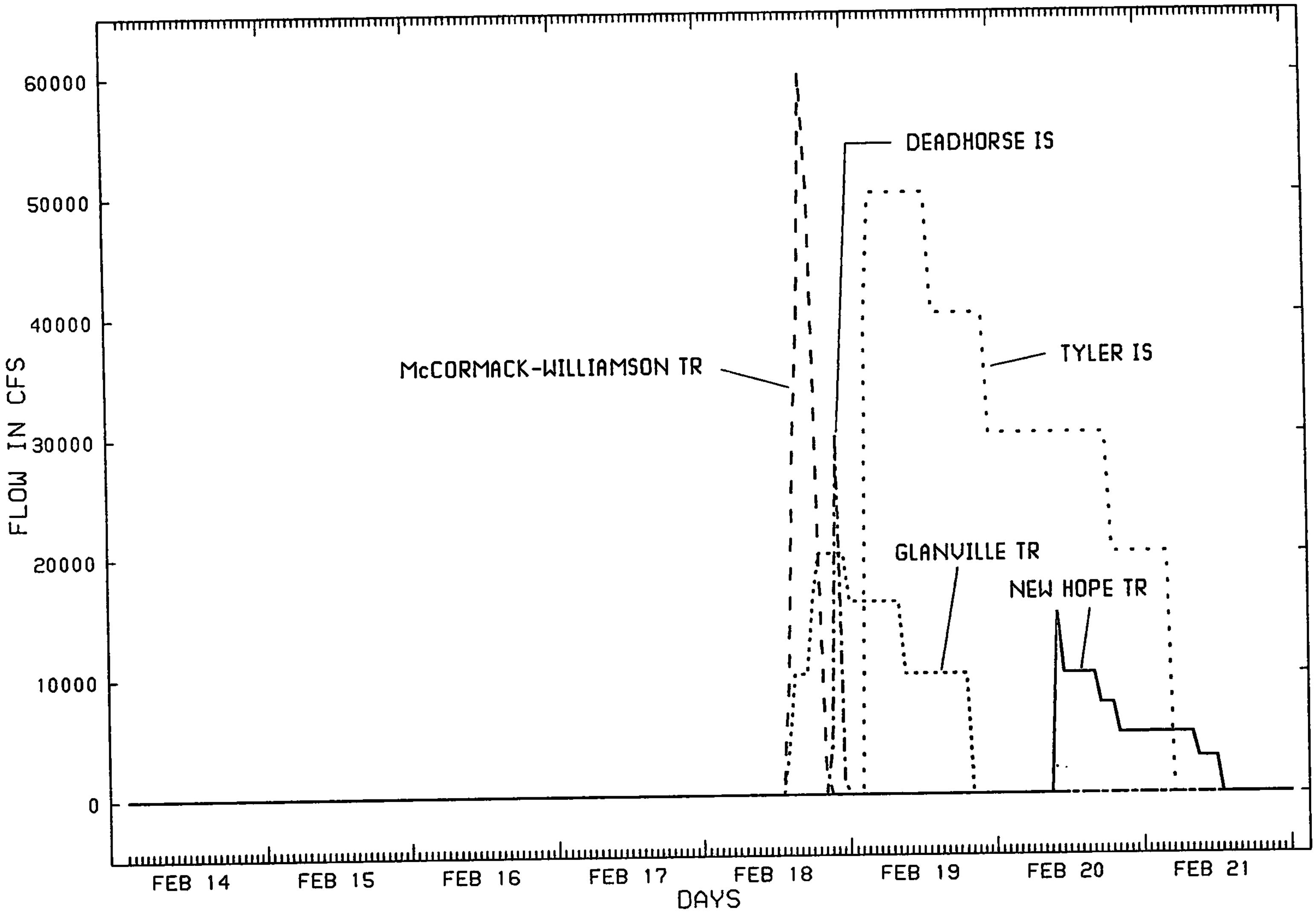
1986 FLOOD
INFLOW HYDROGRAPHS
MORRISON STREAM GROUP



DELTA MODELING SECTION OCT 90

FIGURE C-17

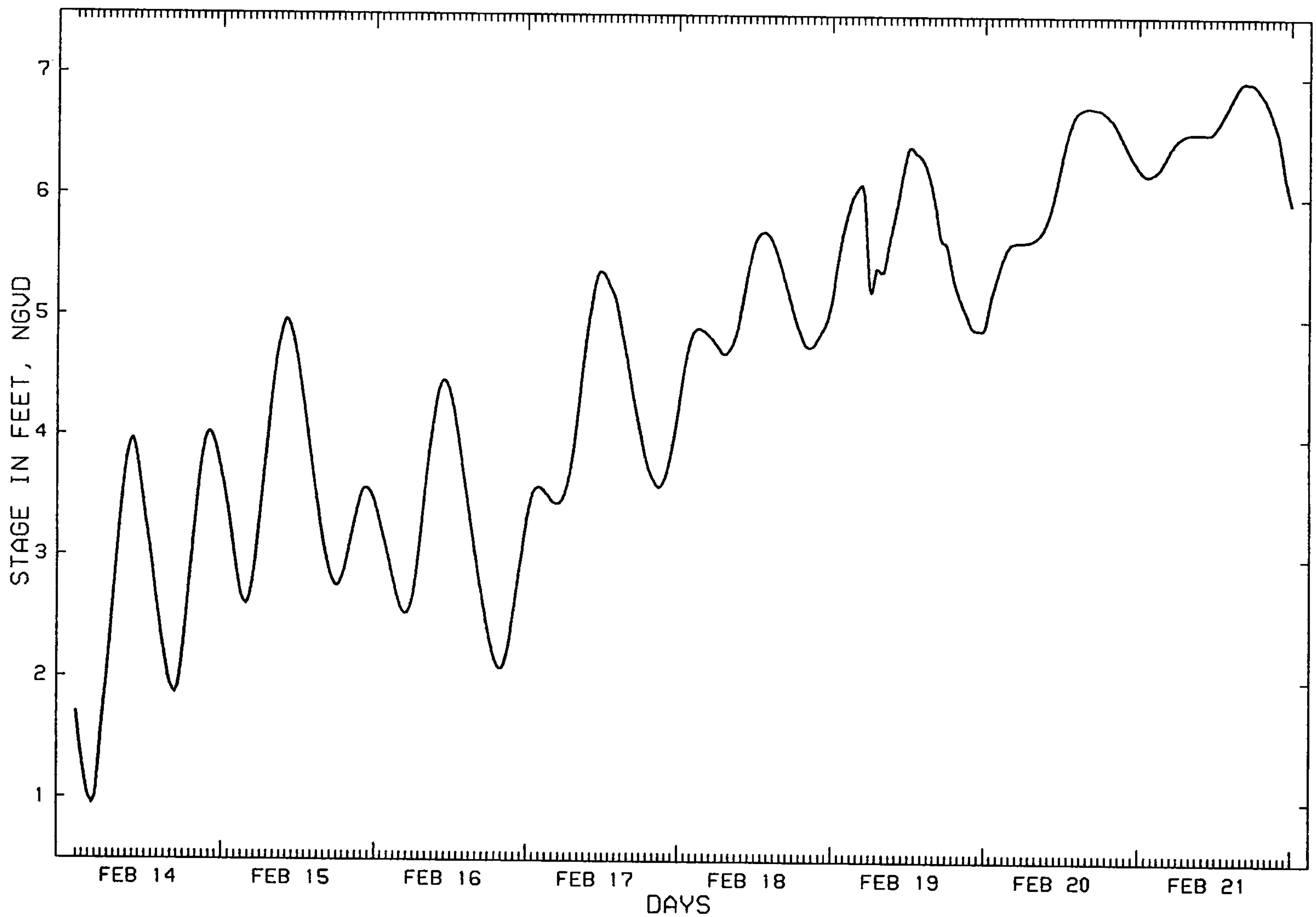
1986 FLOOD
LEVEE BREACH HYDROGRAPHS



DELTA MODELING SECTION OCT 90

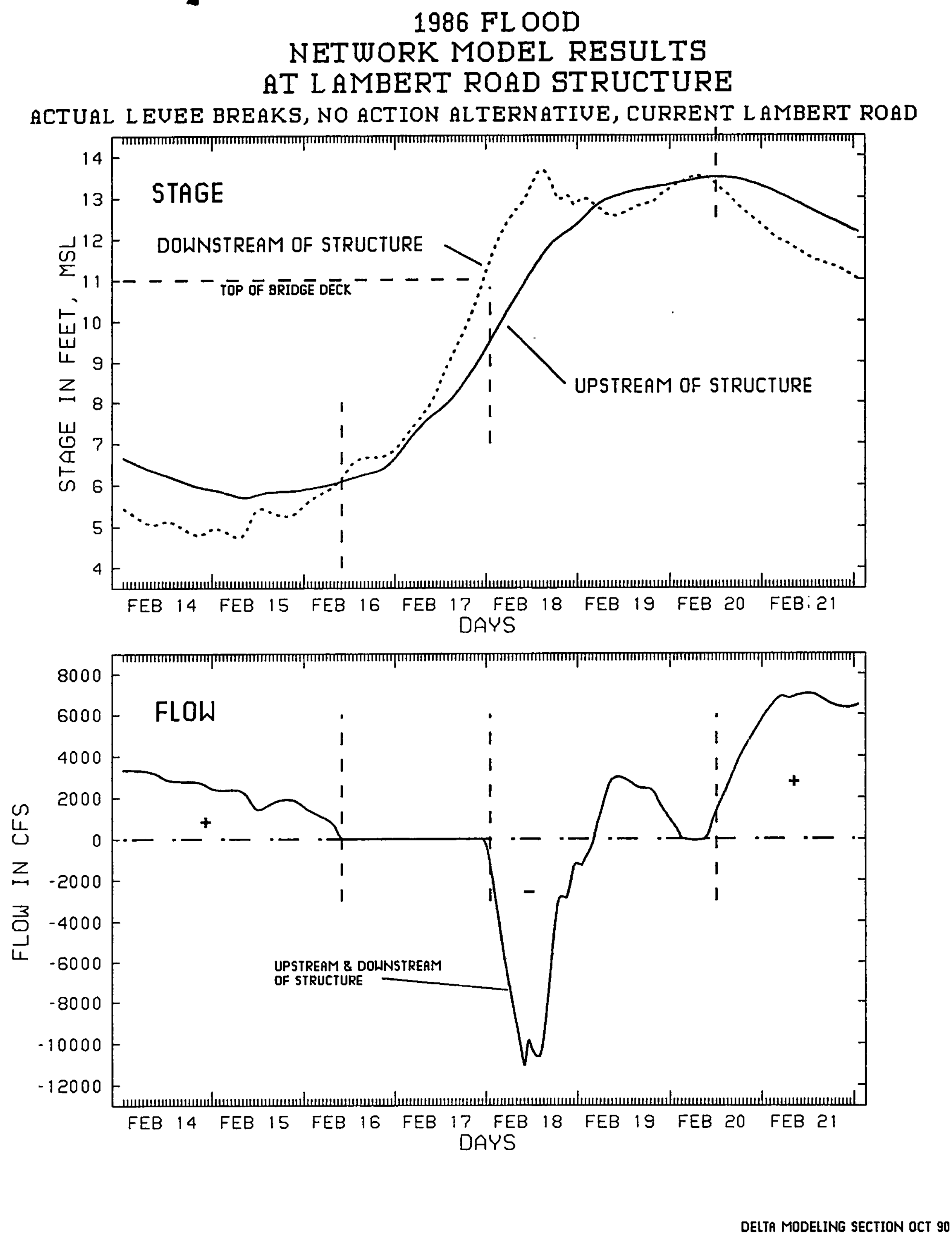
FIGURE C-18

1986 FLOOD
HISTORIC STAGE AT GEORGIANA SLOUGH



DELTA MODELING SECTION OCT 90

FIGURE C-19


1986 FLOOD
NETWORK MODEL RESULTS
AT LAMBERT ROAD STRUCTURE
ACTUAL LEVEE BREAKS, NO ACTION ALTERNATIVE, CURRENT LAMBERT ROAD
STAGE
DOWNSTREAM OF STRUCTURE
TOP OF BRIDGE DECK
UPSTREAM OF STRUCTURE
STAGE IN FEET, MSL
14
13
12
11
10
9
8
7
6
5
4
FEB 14
FEB 15
FEB 16
FEB 17
FEB 18
FEB 19
FEB 20
FEB 21
DAYS
FLOW
FLOW IN CFS
8000
6000
4000
2000
0
-2000
-4000
-6000
-8000
-10000
-12000
+
-
+
UPSTREAM & DOWNSTREAM
OF STRUCTURE
FEB 14
FEB 15
FEB 16
FEB 17
FEB 18
FEB 19
FEB 20
FEB 21
DAYS
DELTA MODELING SECTION OCT 90

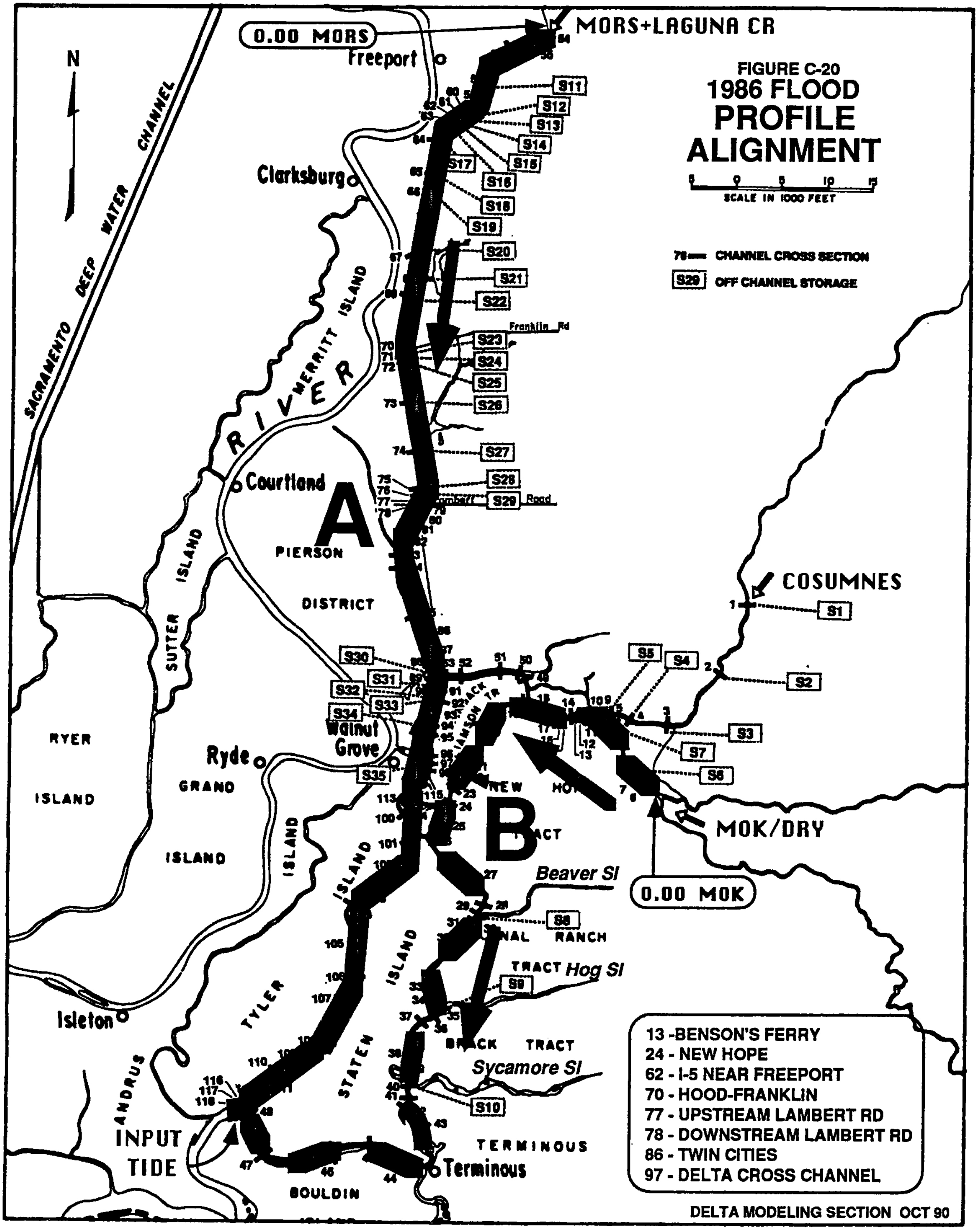


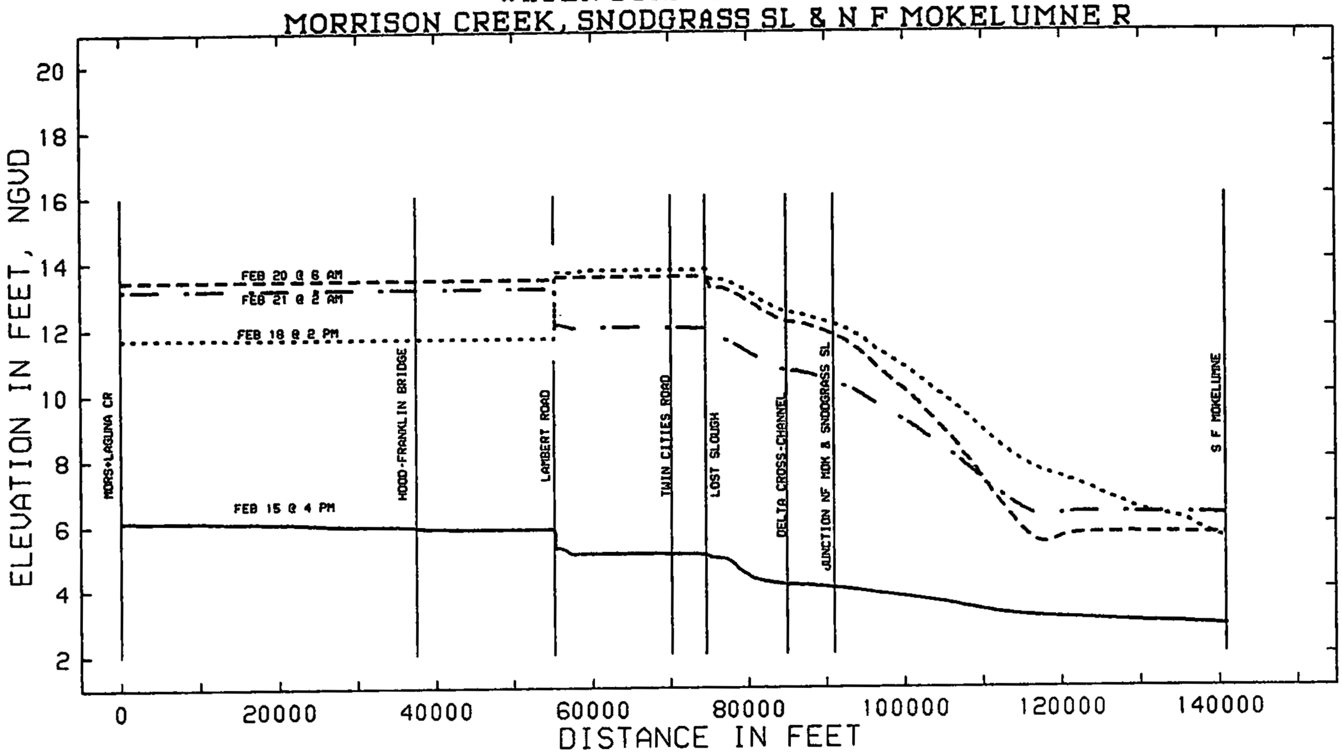
FIGURE C-20
1986 FLOOD
PROFILE
ALIGNMENT
SCALE IN 1000 FEET
CHANNEL CROSS SECTION
OFF CHANNEL STORAGE
0.00 MORS
MORS+LAGUNA CR
Freeport
Clarksburg
Courtland
Walnut Grove
Ryde
Isleton
Terminous
COSUMNES
MOK/DRY
0.00 MOK
INPUT TIDE
SACRAMENTO DEEP WATER CHANNEL
MERRITT ISLAND
RIVER
SUTTER ISLAND
PIERSON DISTRICT
RYER ISLAND
GRAND ISLAND
TYLER ISLAND
STATEN ISLAND
ANDRUS
BOULDIN
TERMINOUS
Beaver Sl
Hog Sl
Sycamore Sl
RANCH
TRACT
Franklin Rd
13 -BENSON'S FERRY
24 - NEW HOPE
62 - I-5 NEAR FREEPORT
70 - HOOD-FRANKLIN
77 - UPSTREAM LAMBERT RD
78 - DOWNSTREAM LAMBERT RD
86 - TWIN CITIES
97 - DELTA CROSS CHANNEL
DELTA MODELING SECTION OCT 90

FIGURE C-21

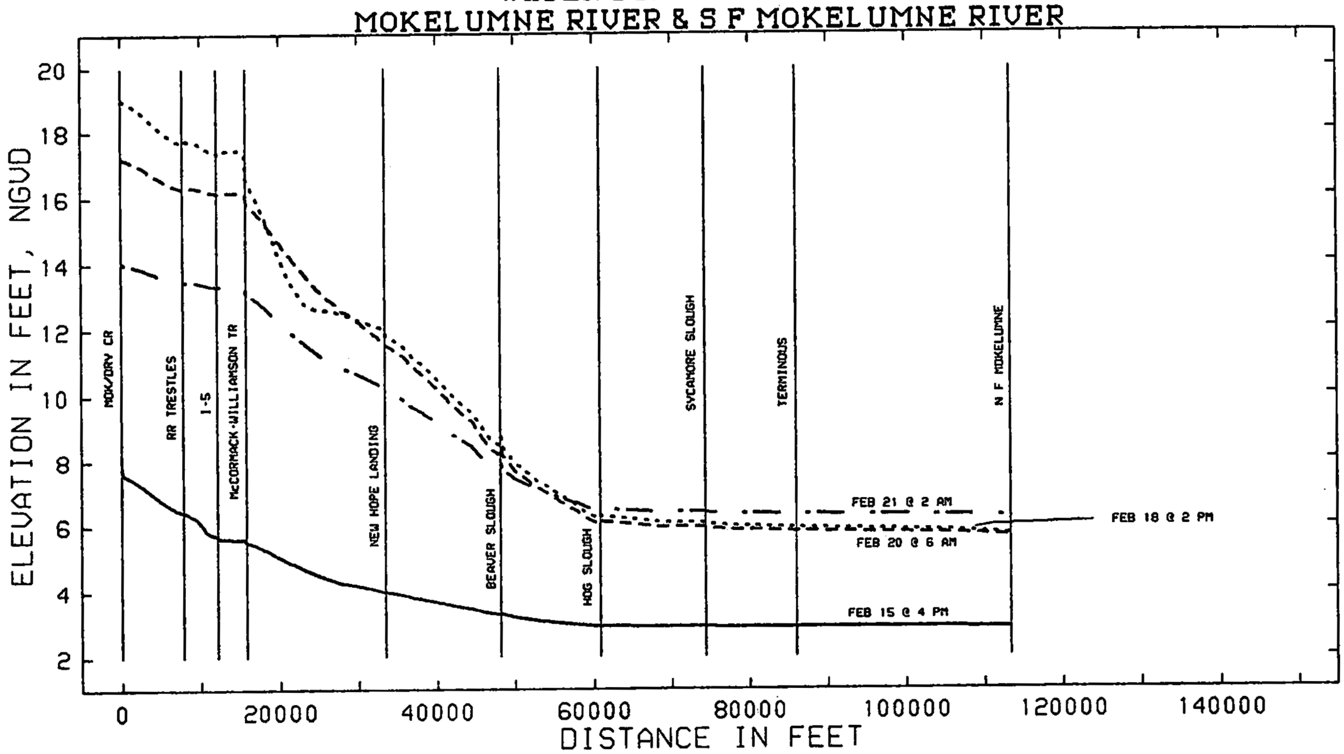
1986 FLOOD

ACTUAL LEVEE BREAKS, NO ACTION ALTERNATIVE, CURRENT LAMBERT ROAD

WATER SURFACE PROFILE A
MORRISON CREEK, SNODGRASS SL & N F MOKELUMNE R



WATER SURFACE PROFILE B
MOKELUMNE RIVER & S F MOKELUMNE RIVER



DELTA MODELING SECTION OCT 90

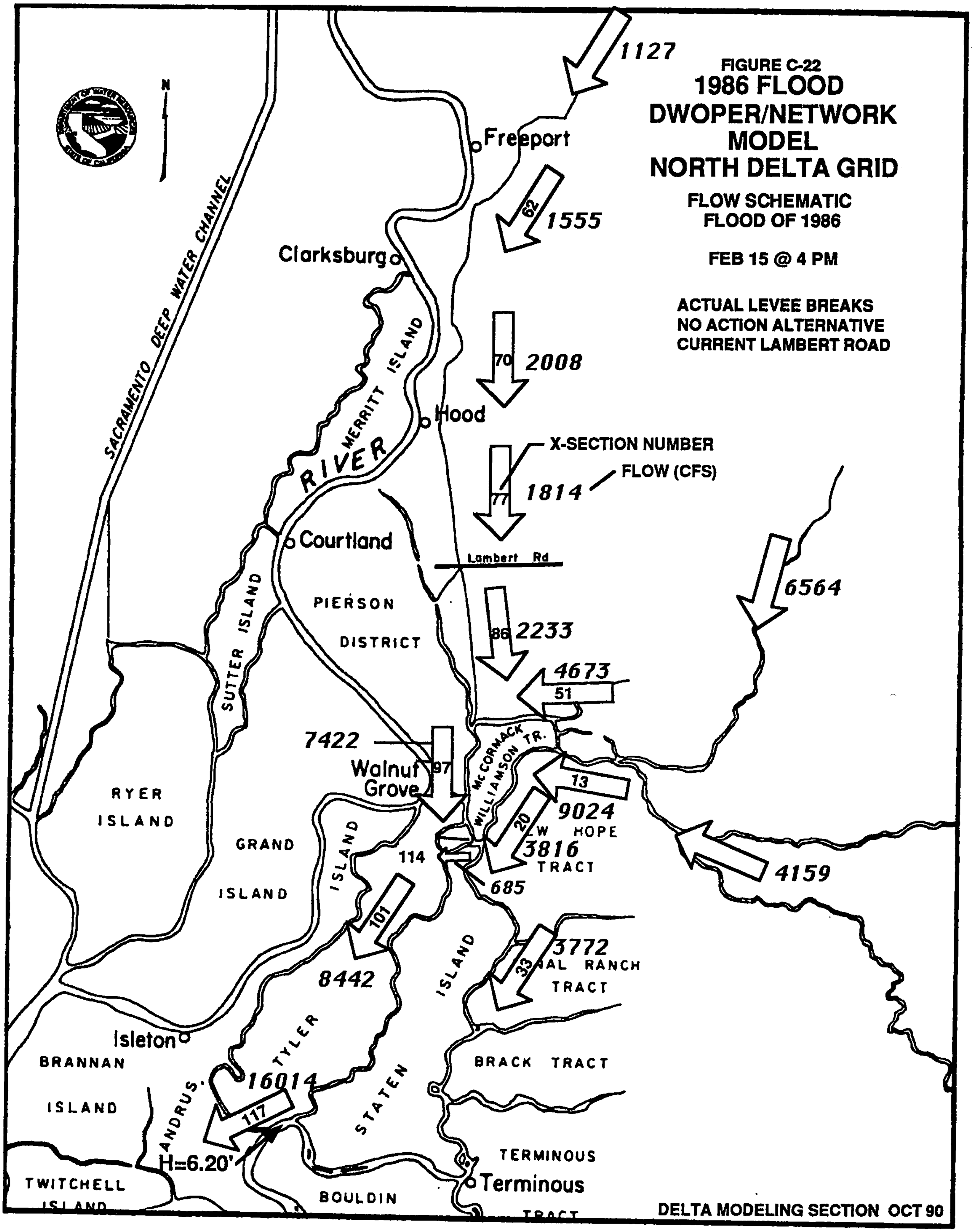


FIGURE C-22
1986 FLOOD
DWOPER/NETWORK MODEL
NORTH DELTA GRID
FLOW SCHEMATIC
FLOOD OF 1986
FEB 15 @ 4 PM
ACTUAL LEVEE BREAKS
NO ACTION ALTERNATIVE
CURRENT LAMBERT ROAD
X-SECTION NUMBER
FLOW (CFS)
1127
1555
62
2008
70
1814
77
2233
86
4673
51
6564
7422
97
9024
13
3816
20
4159
685
114
8442
101
3772
33
16014
117
H=6.20'
N
Freeport
Clarksburg
Hood
Courtland
Walnut Grove
Isleton
Terminous
SACRAMENTO DEEP WATER CHANNEL
RIVER
MERRITT ISLAND
SUTTER ISLAND
PIERSON DISTRICT
Lambert Rd
McCORMACK WILLIAMSON TR.
RYER ISLAND
GRAND ISLAND
ISLAND
NEW HOPE TRACT
ISLAND
RANCH TRACT
BRACK TRACT
TYLER
ANDRUS
STATEN
BRANNAN ISLAND
TWITCHELL ISLAND
BOULDIN
TERMINOUS TRACT
DELTA MODELING SECTION OCT 90

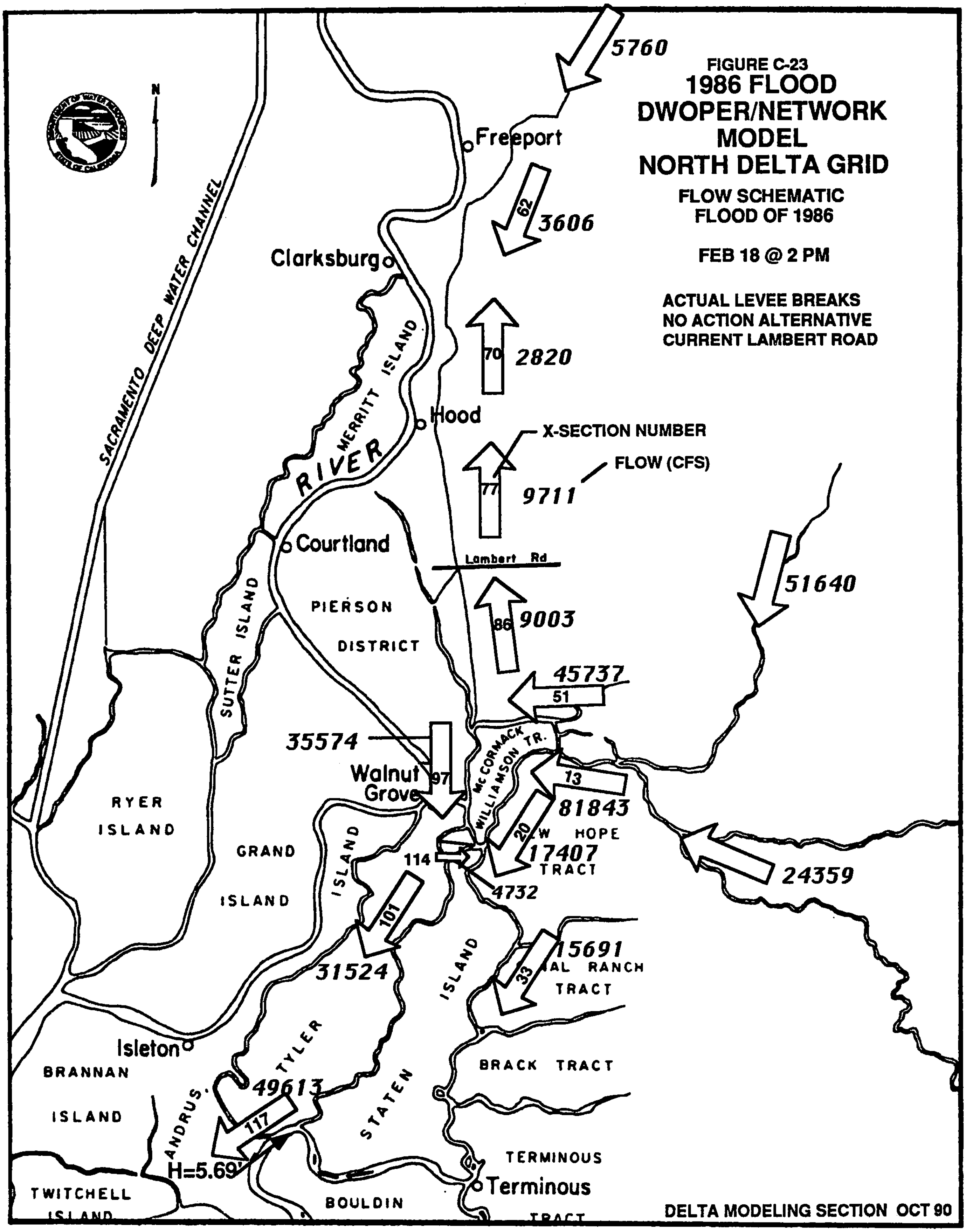


FIGURE C-23
1986 FLOOD
DWOPER/NETWORK
MODEL
NORTH DELTA GRID
FLOW SCHEMATIC
FLOOD OF 1986
FEB 18 @ 2 PM
ACTUAL LEVEE BREAKS
NO ACTION ALTERNATIVE
CURRENT LAMBERT ROAD
X-SECTION NUMBER
FLOW (CFS)
N
5760
Freeport
62
3606
Clarksburg
70
2820
Hood
77
9711
Lambert Rd
86
9003
51640
45737
51
SACRAMENTO DEEP WATER CHANNEL
MERRITT ISLAND
RIVER
Courtland
PIERSON
DISTRICT
SUTTER ISLAND
35574
Walnut Grove
97
McCORMACK WILLIAMSON TR.
13
81843
20
17407
W HOPE
TRACT
24359
RYER
ISLAND
GRAND
ISLAND
114
4732
101
31524
15691
33
AL RANCH
TRACT
Isleton
BRANNAN
ISLAND
TYLER
ISLAND
49613
117
ANDRUS
H=5.69'
STATEN
BRACK TRACT
TERMINOUS
Terminous
TWITCHELL
BOULDIN
DELTA MODELING SECTION OCT 90

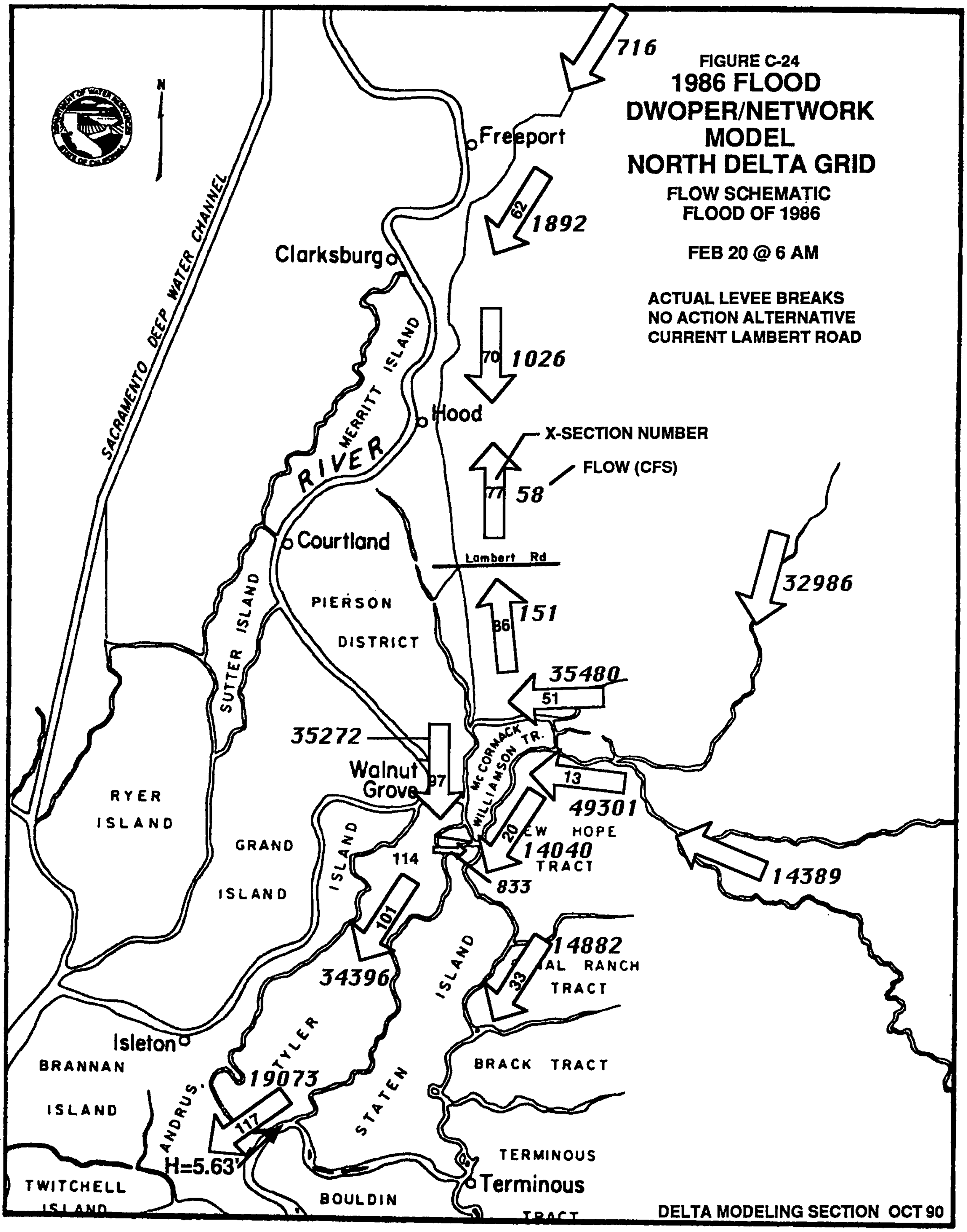


FIGURE C-24
1986 FLOOD
DWOPER/NETWORK
MODEL
NORTH DELTA GRID
FLOW SCHEMATIC
FLOOD OF 1986
FEB 20 @ 6 AM
ACTUAL LEVEE BREAKS
NO ACTION ALTERNATIVE
CURRENT LAMBERT ROAD
716
Freeport
62
1892
Clarksburg
SACRAMENTO DEEP WATER CHANNEL
MERRITT ISLAND
70
1026
Hood
RIVER
X-SECTION NUMBER
FLOW (CFS)
77
58
Courtland
Lambert Rd
PIERSON
DISTRICT
86
151
SUTTER ISLAND
32986
35480
51
35272
97
Walnut
Grove
McCORMACK WILLIAMSON TR.
13
49301
RYER
ISLAND
GRAND
ISLAND
114
ISLAND
20
14040
NEW HOPE
TRACT
833
14389
101
34396
14882
33
ISLAND
RANCH
TRACT
Isleton
TYLER
BRANNAN
ISLAND
19073
STATEN
BRACK TRACT
ANDRUS
117
H=5.63'
TERMINOUS
Terminous
TWITCHELL
ISLAND
BOULDIN
TRACT
DELTA MODELING SECTION OCT 90

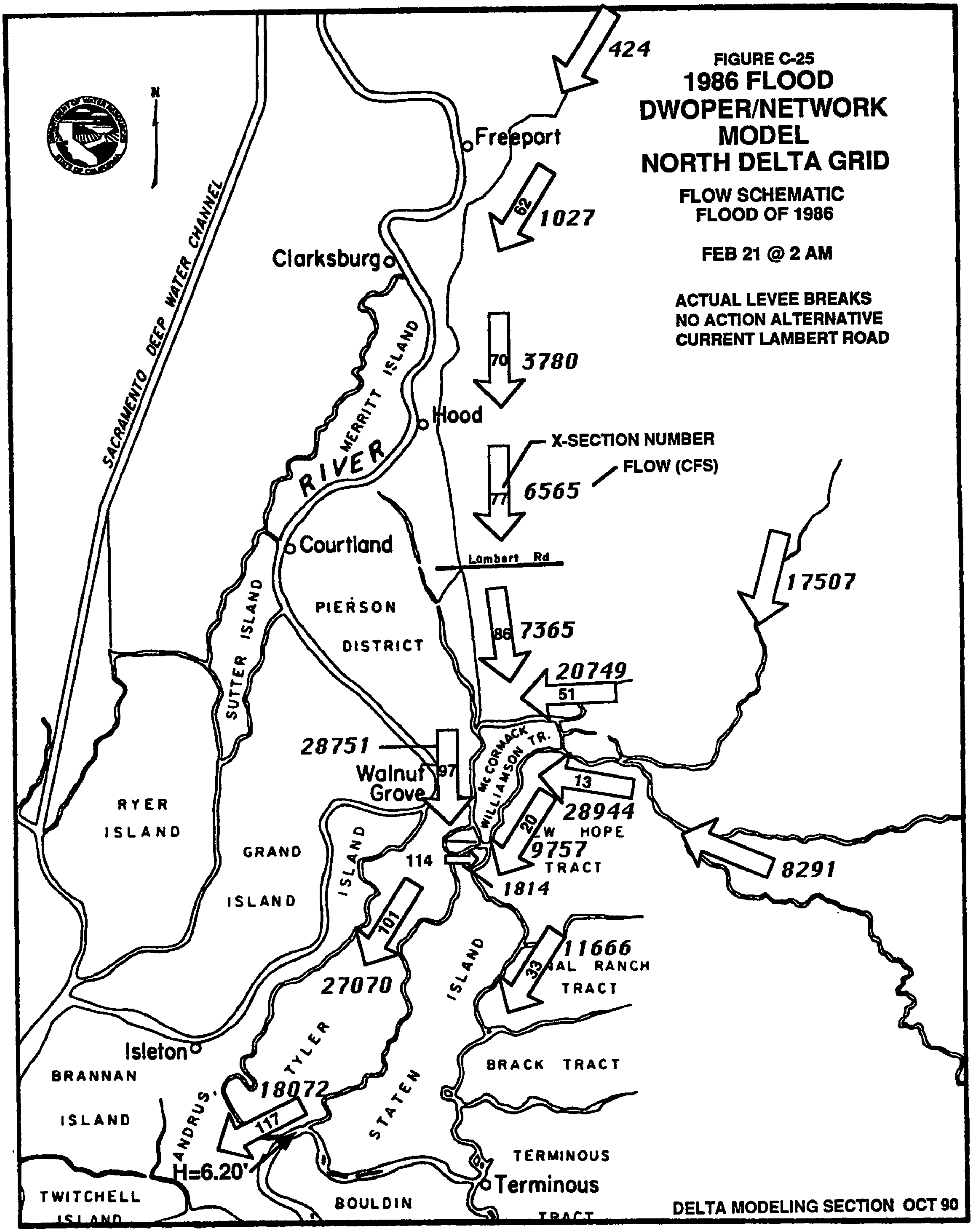
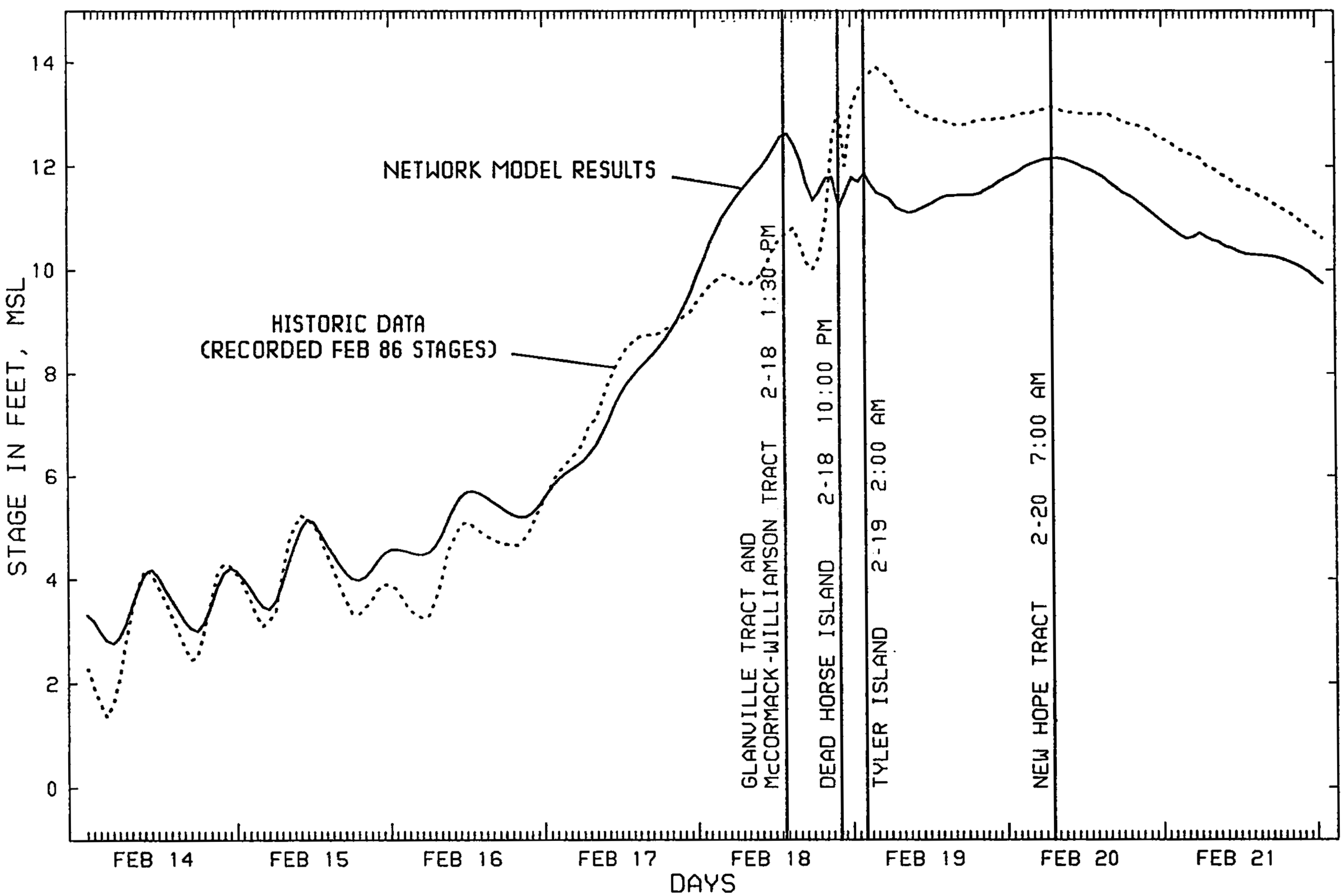


FIGURE C-25
1986 FLOOD
DWOPER/NETWORK
MODEL
NORTH DELTA GRID
FLOW SCHEMATIC
FLOOD OF 1986
FEB 21 @ 2 AM
ACTUAL LEVEE BREAKS
NO ACTION ALTERNATIVE
CURRENT LAMBERT ROAD
N
424
Freeport
62
1027
Clarksburg
SACRAMENTO DEEP WATER CHANNEL
MERRITT ISLAND
RIVER
70
3780
Hood
X-SECTION NUMBER
FLOW (CFS)
77
6565
Courtland
Lambert Rd
17507
PIERSON
DISTRICT
SUTTER ISLAND
86
7365
20749
51
28751
97
Walnut
Grove
McCORMACK WILLIAMSON TR.
13
28944
20
HOPE
9757
TRACT
8291
RYER
ISLAND
GRAND
ISLAND
114
1814
101
11666
33
RANCH
TRACT
27070
TYLER
ISLAND
BRACK TRACT
Isleton
BRANNAN
ISLAND
18072
117
ANDRUS
STATEN
H=6.20'
TERMINOUS
Terminous
TWITCHELL
BOULDIN
DELTA MODELING SECTION OCT 90

FIGURE C-26

1986 FLOOD
STAGE AT DELTA CROSS CHANNEL
ACTUAL LEVEE BREAKS, NO ACTION ALTERNATIVE, CURRENT LAMBERT ROAD

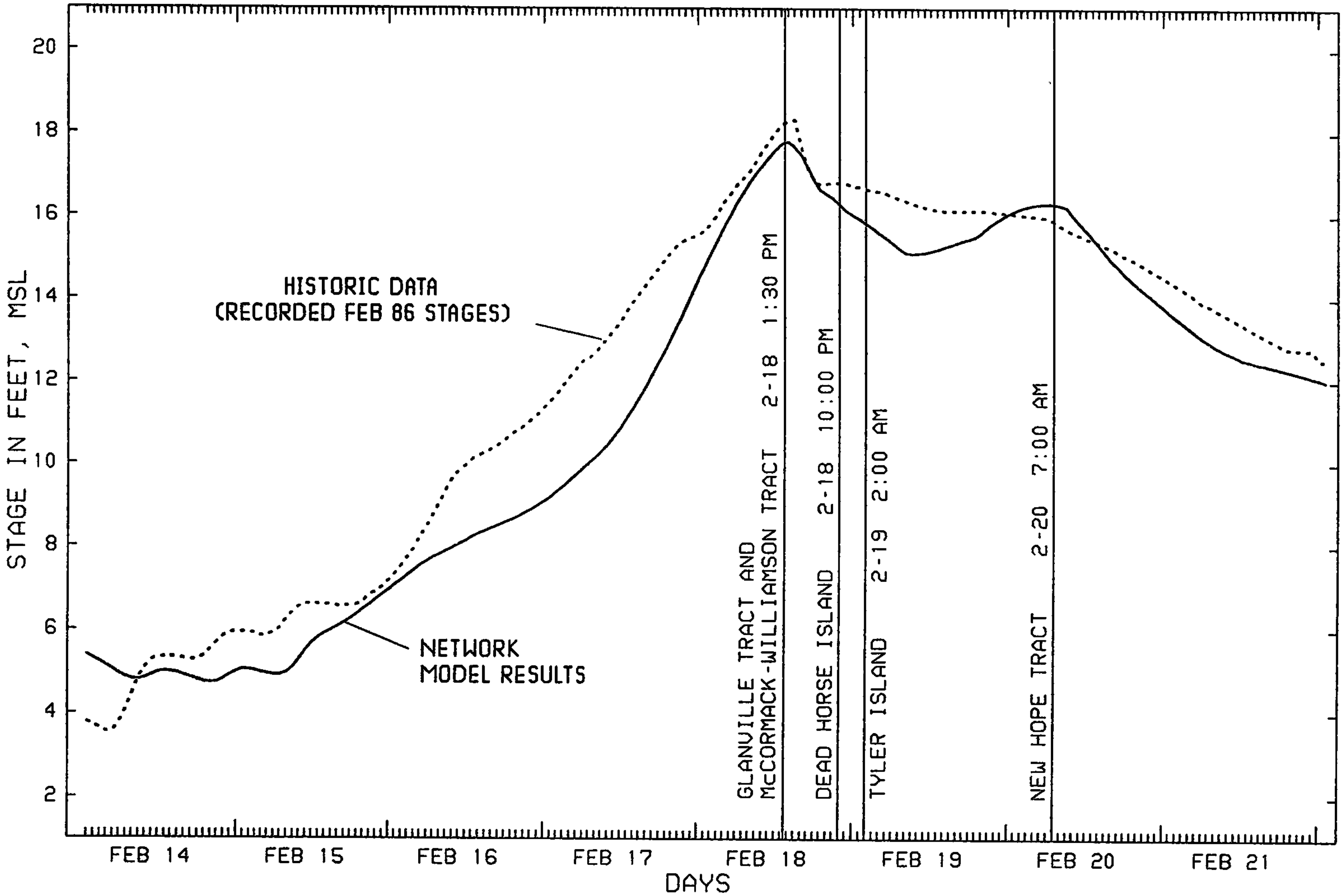


DELTA MODELING SECTION OCT 90

368

FIGURE C-27

1986 FLOOD
STAGE AT BENSON'S FERRY
ACTUAL LEVEE BREAKS, NO ACTION ALTERNATIVE, CURRENT LAMBERT ROAD

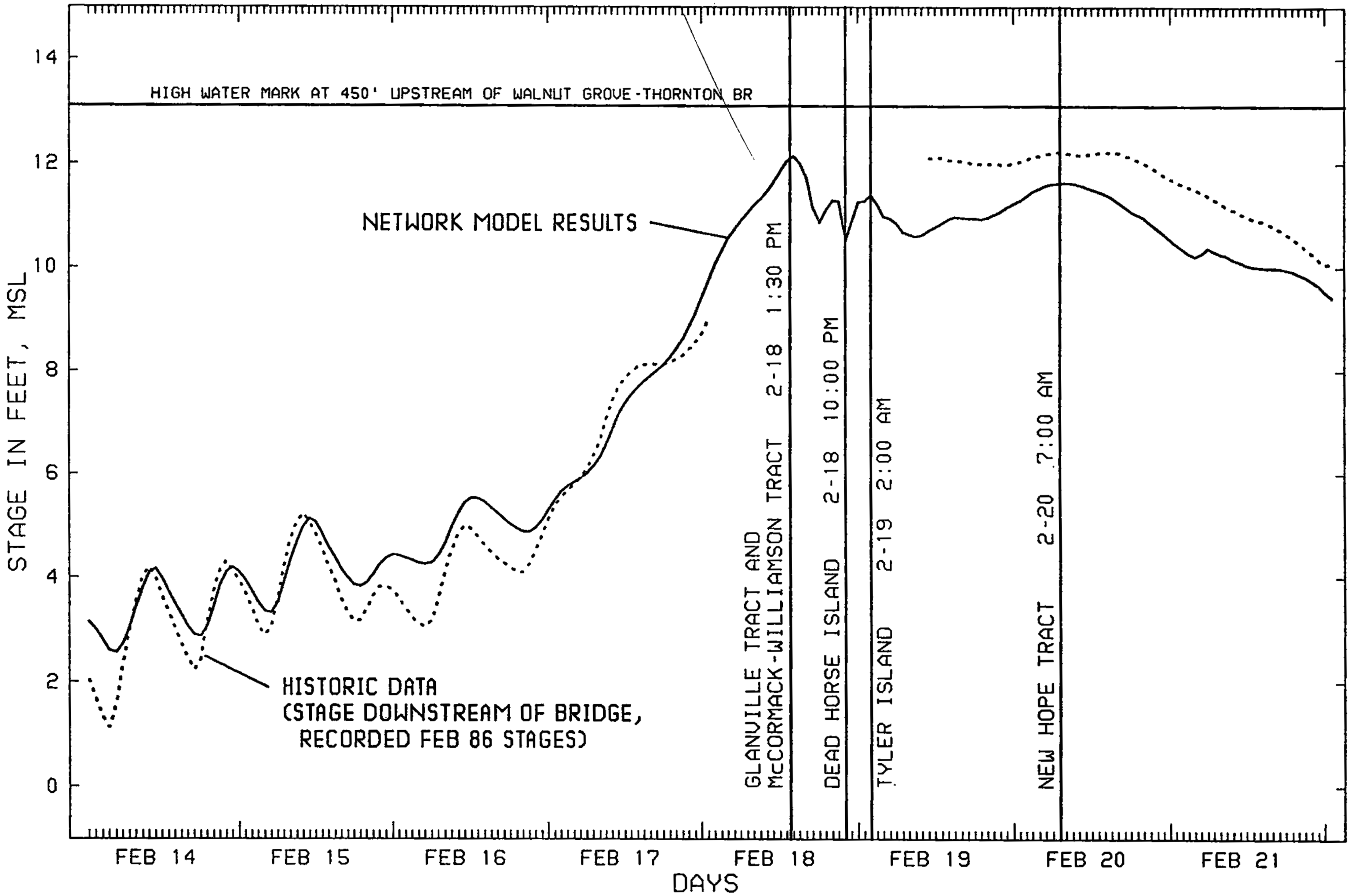


DELTA MODELING SECTION OCT 90

FIGURE C-28

1986 FLOOD
STAGE AT NEW HOPE

ACTUAL LEVEE BREAKS, NO ACTION ALTERNATIVE, CURRENT LAMBERT ROAD



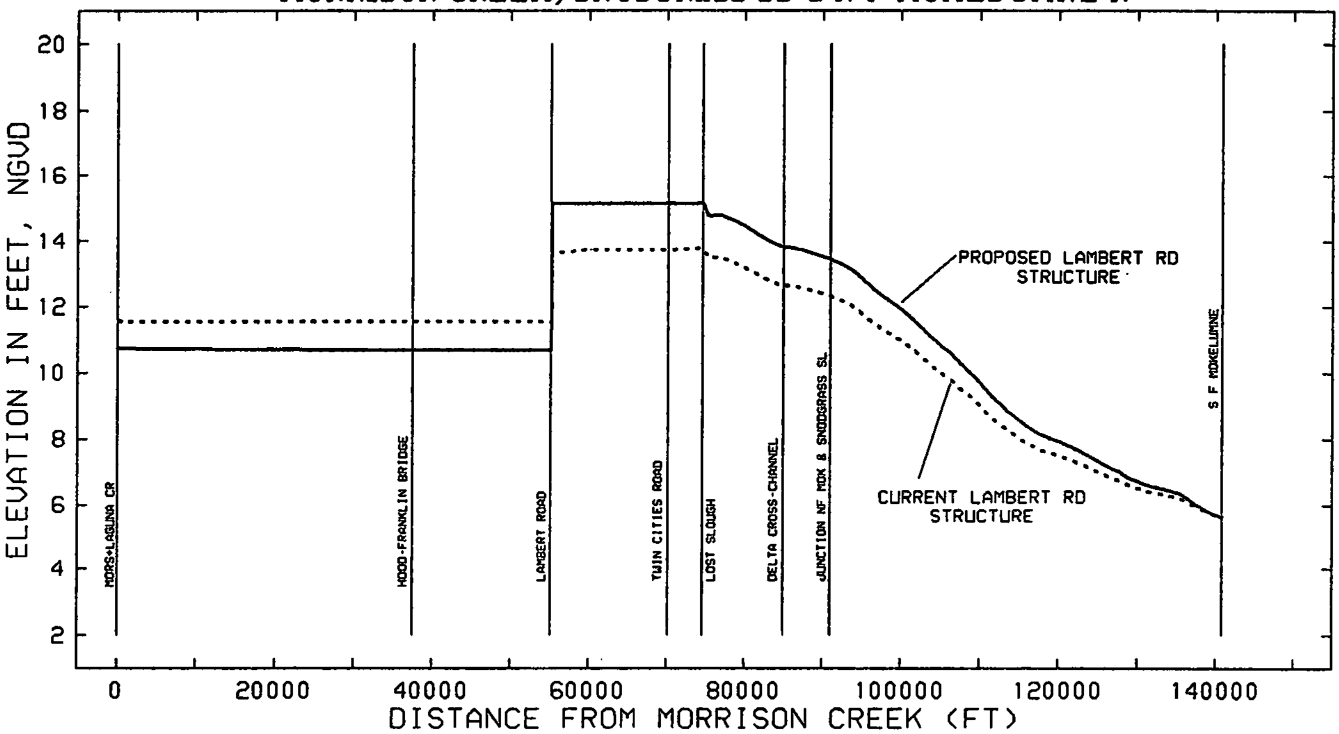
DELTA MODELING SECTION OCT 90

FIGURE C-29

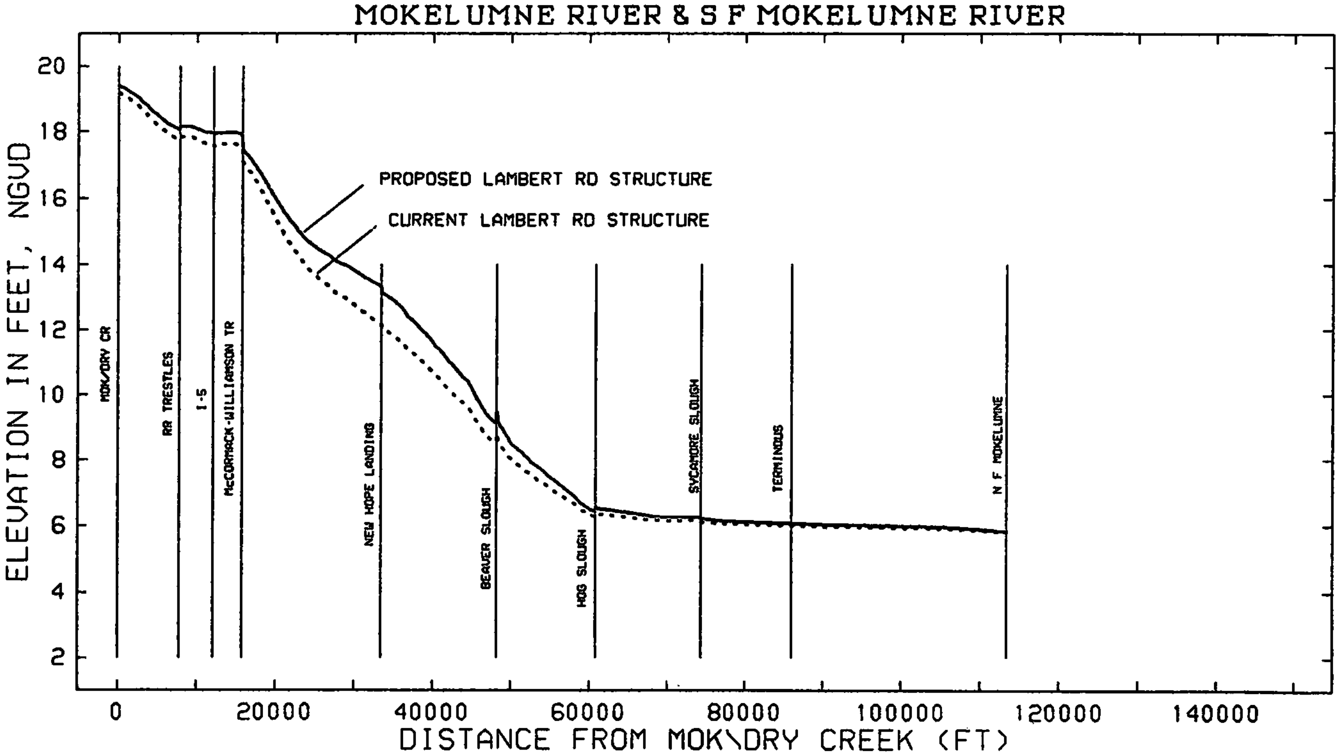
1986 FLOOD MODEL SIMULATION RESULTS

ACTUAL LEVEE BREAKS, NO ACTION ALTERNATIVE, CURRENT VS PROPOSED LAMBERT ROAD

WATER SURFACE PROFILE A
MORRISON CREEK, SNODGRASS SL & N F MOKELUMNE R



WATER SURFACE PROFILE B
MOKELUMNE RIVER & S F MOKELUMNE RIVER



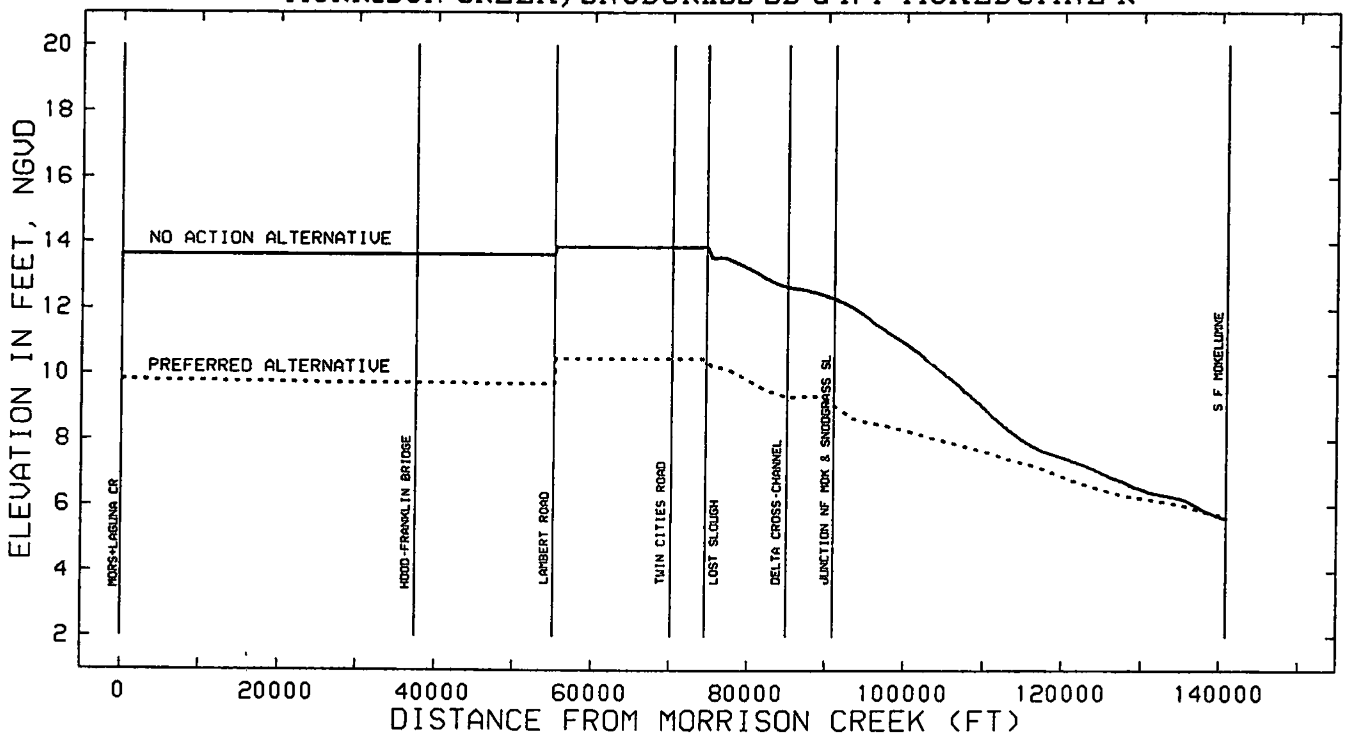
DELTA MODELING SECTION OCT 90

FIGURE C-30

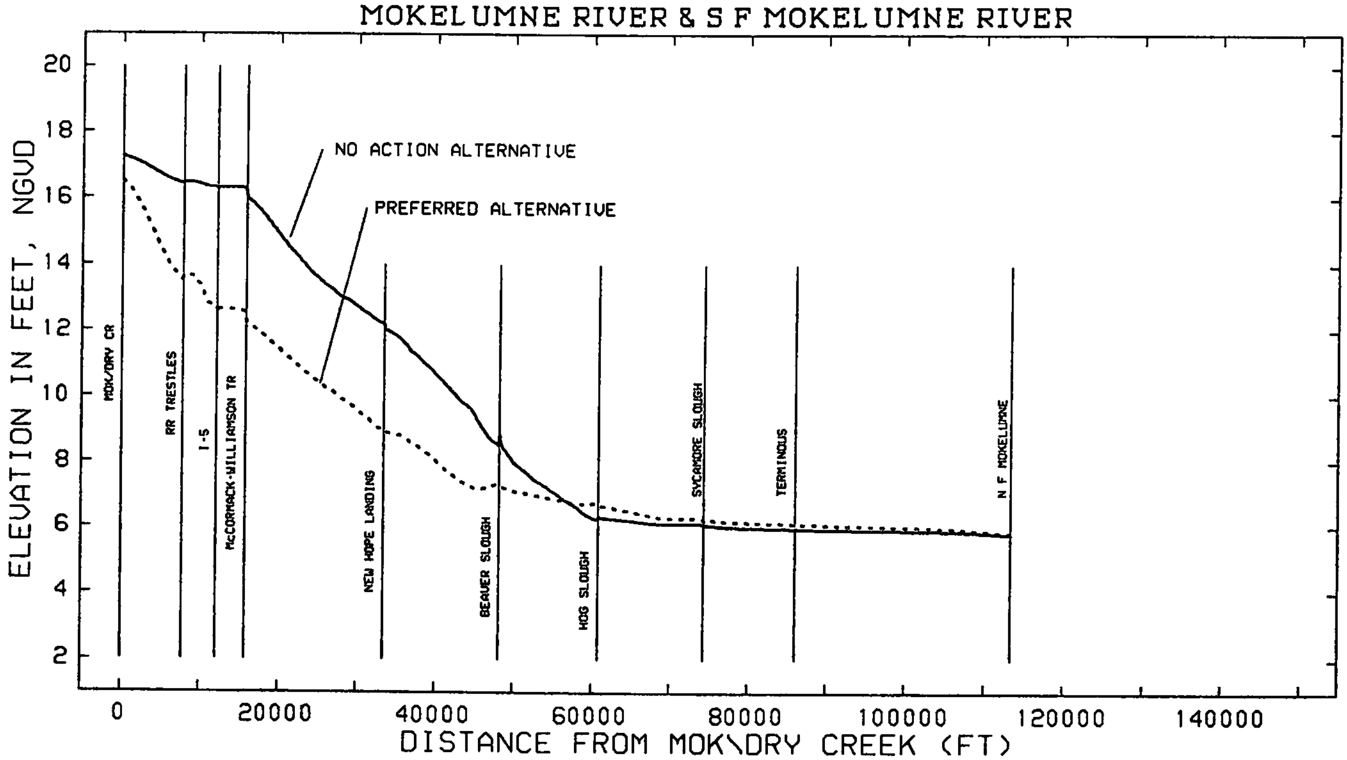
1986 FLOOD
MODEL SIMULATION RESULTS

McCORMACK-WILLIAMSON & GLANVILLE LEVEE BREAKS, NO ACTION ALTERNATIVE, CURRENT LAMBERT RD VS PREFERRED ALTERNATIVE, CURRENT LAMBERT RD

WATER SURFACE PROFILE A
MORRISON CREEK, SNODGRASS SL & N F MOKELUMNE R



WATER SURFACE PROFILE B
MOKELUMNE RIVER & S F MOKELUMNE RIVER



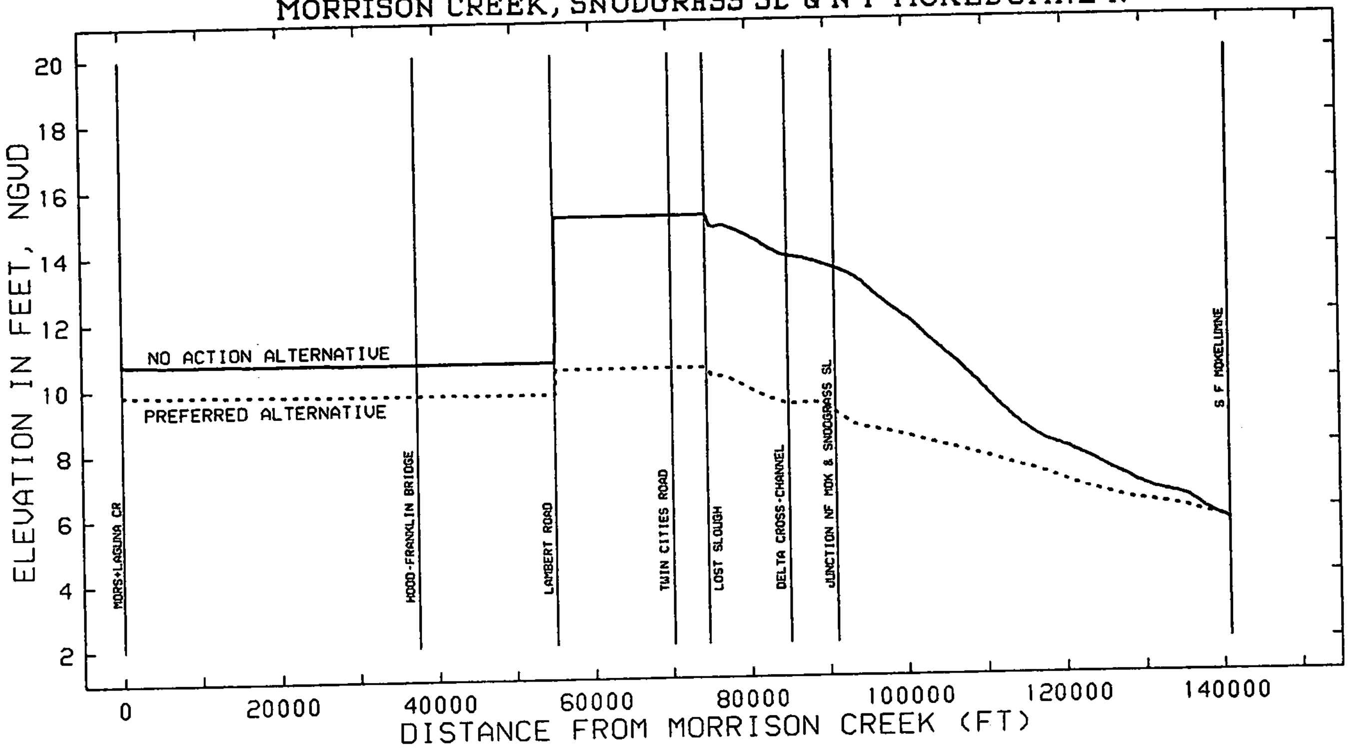
DELTA MODELING SECTION OCT 90

FIGURE C-31

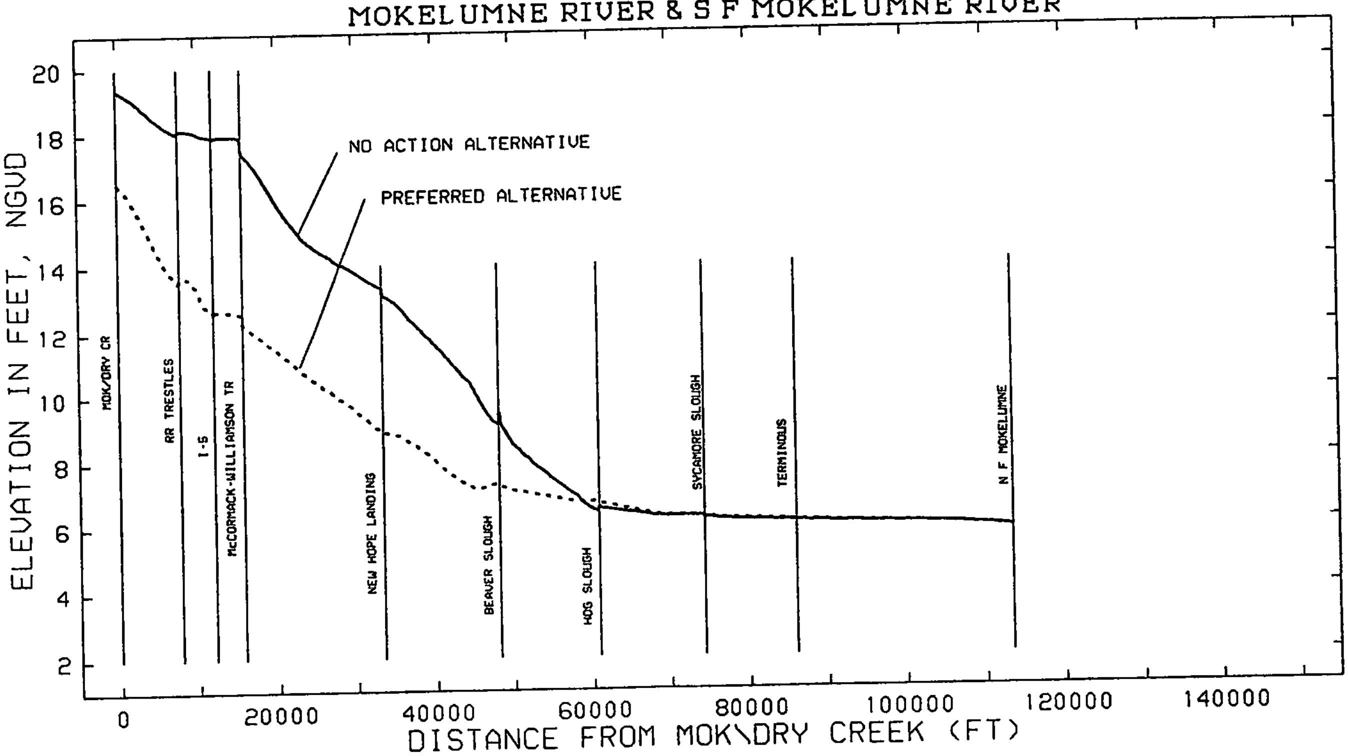
1986 FLOOD MODEL SIMULATION RESULTS

McCORMACK-WILLIAMSON & GLANVILLE LEVEE BREAKS, NO ACTION ALTERNATIVE, PROPOSED LAMBERT RD VS PREFERRED ALTERNATIVE, PROPOSED LAMBERT RD

WATER SURFACE PROFILE A
MORRISON CREEK, SNODGRASS SL & N F MOKELUMNE R



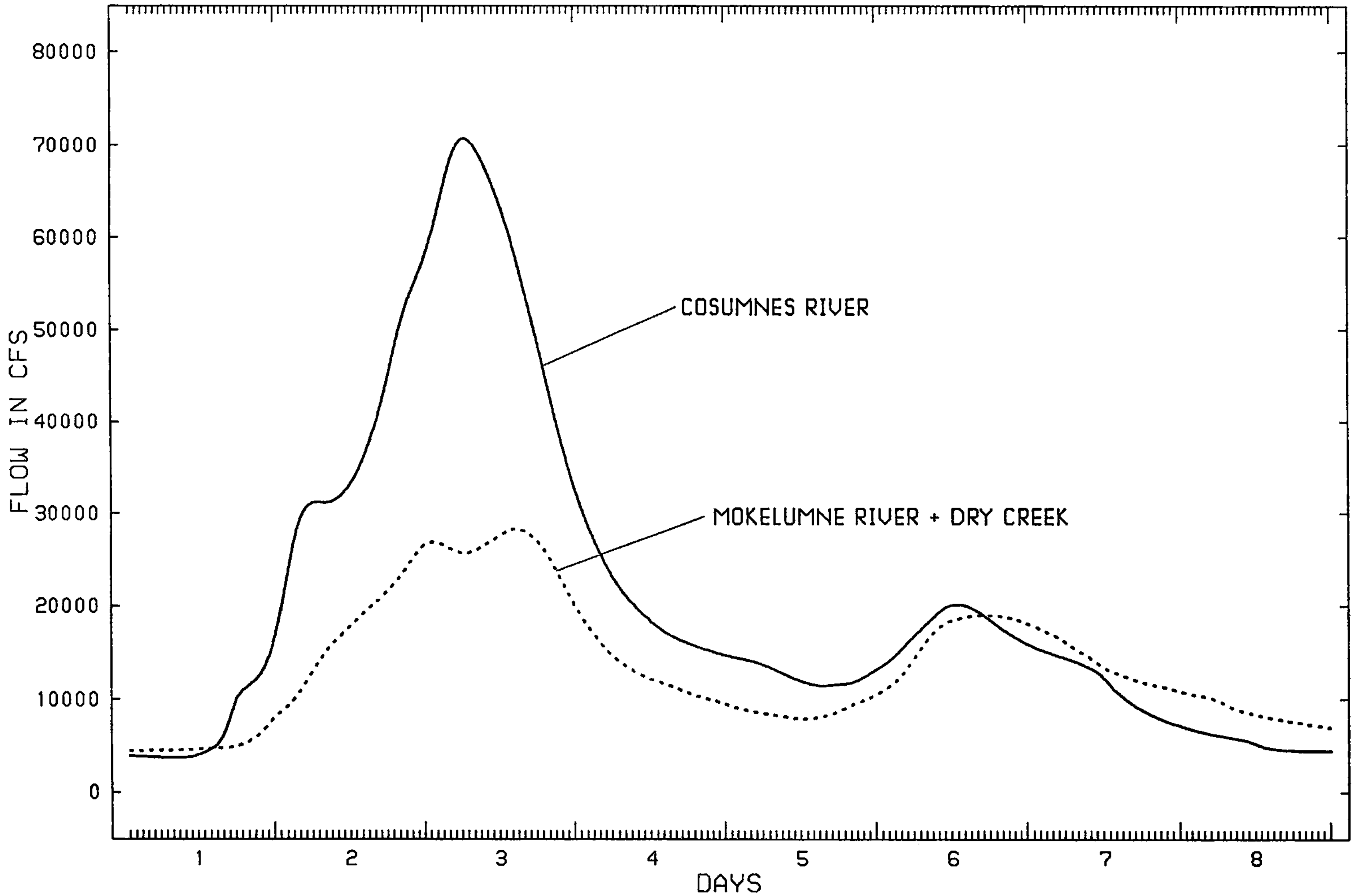
WATER SURFACE PROFILE B
MOKELUMNE RIVER & S F MOKELUMNE RIVER



DELTA MODELING SECTION OCT 90

FIGURE C-32

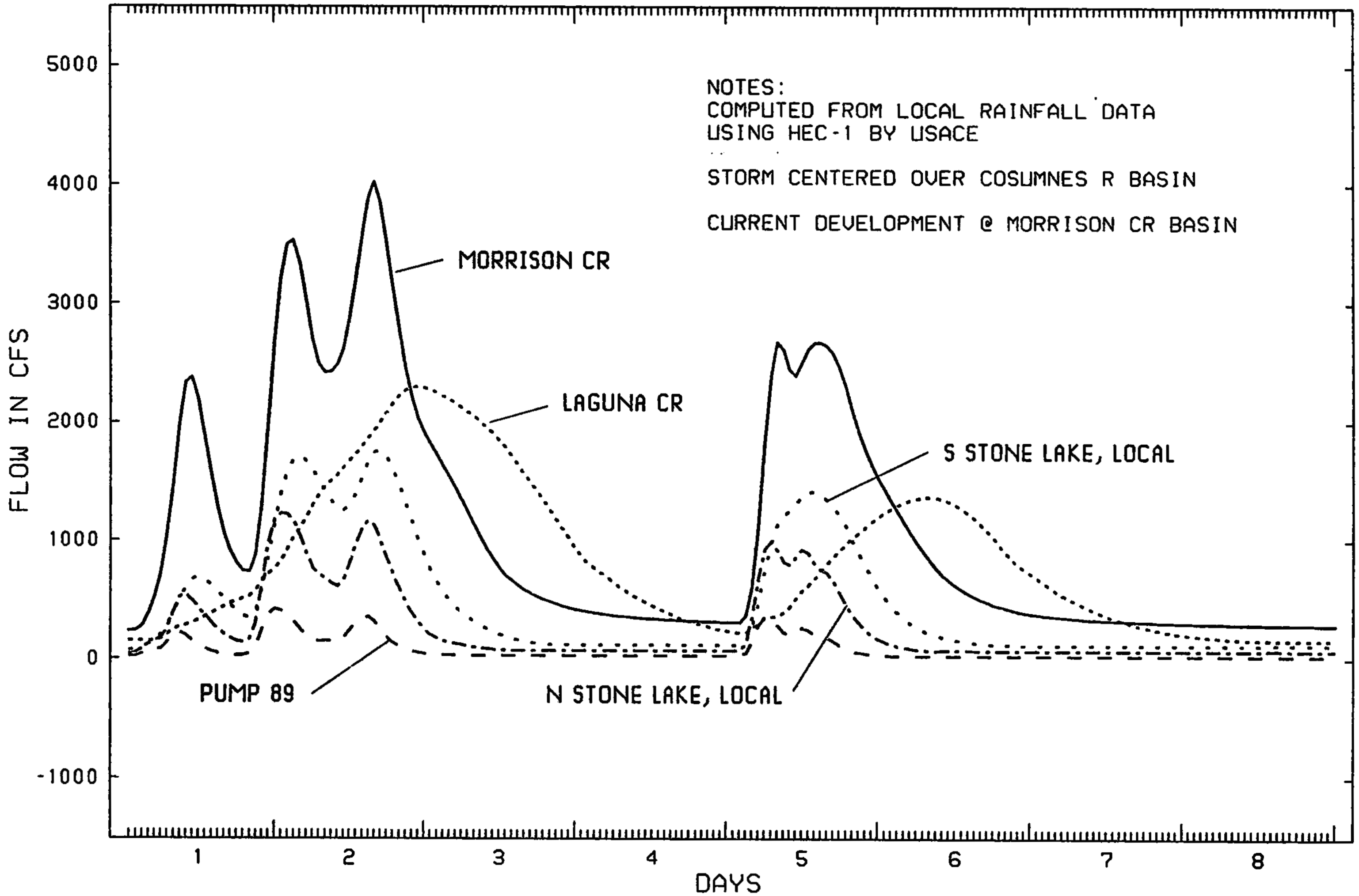
100-YEAR FLOOD
INFLOW HYDROGRAPHS
MOKELUMNE RIVER AND TRIBUTARIES



DELTA MODELING SECTION OCT 90

FIGURE C-33

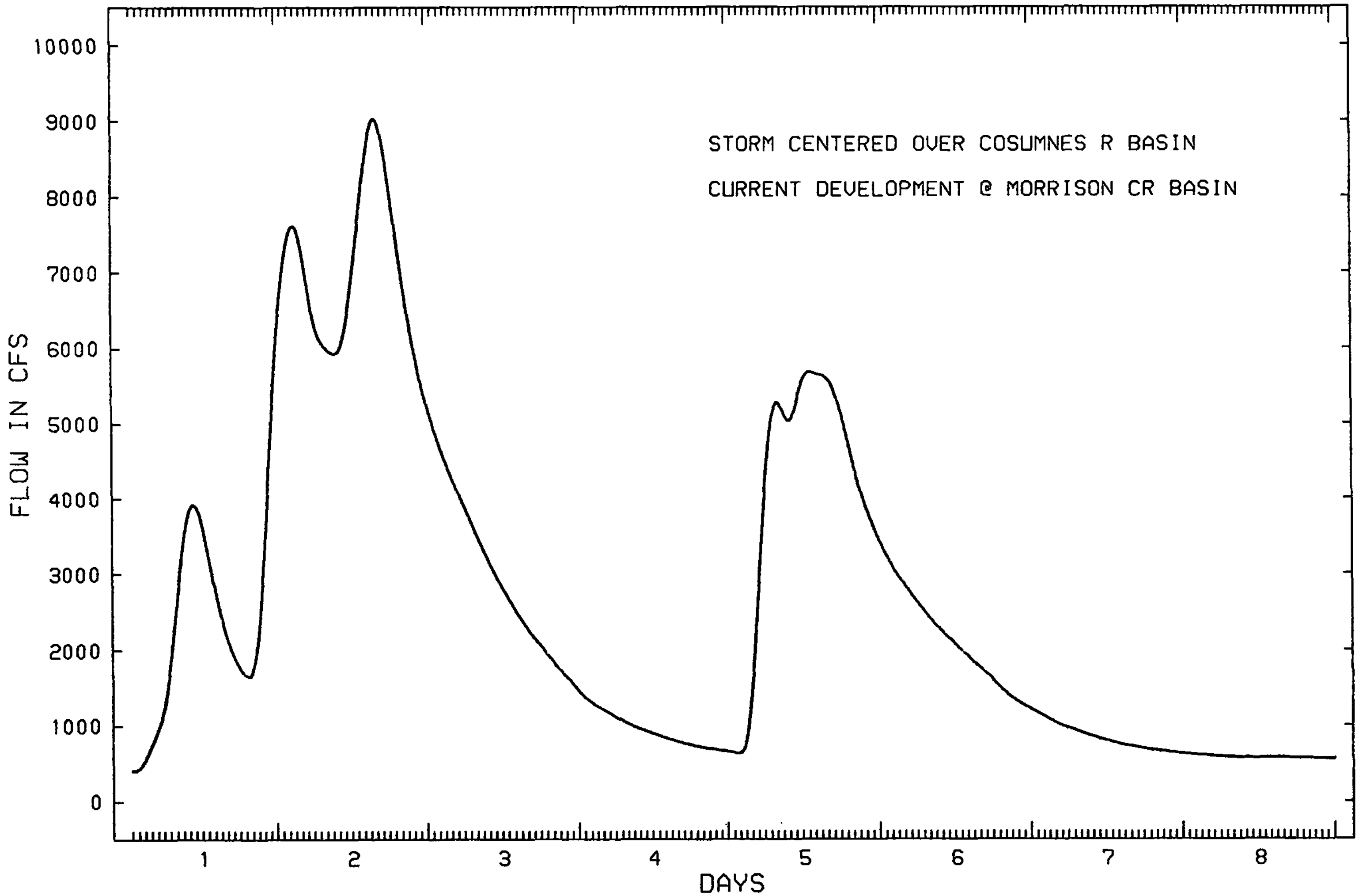
100-YEAR FLOOD
INFLOW HYDROGRAPHS
MORRISON STREAM GROUP



DELTA MODELING SECTION OCT 90

FIGURE C-34

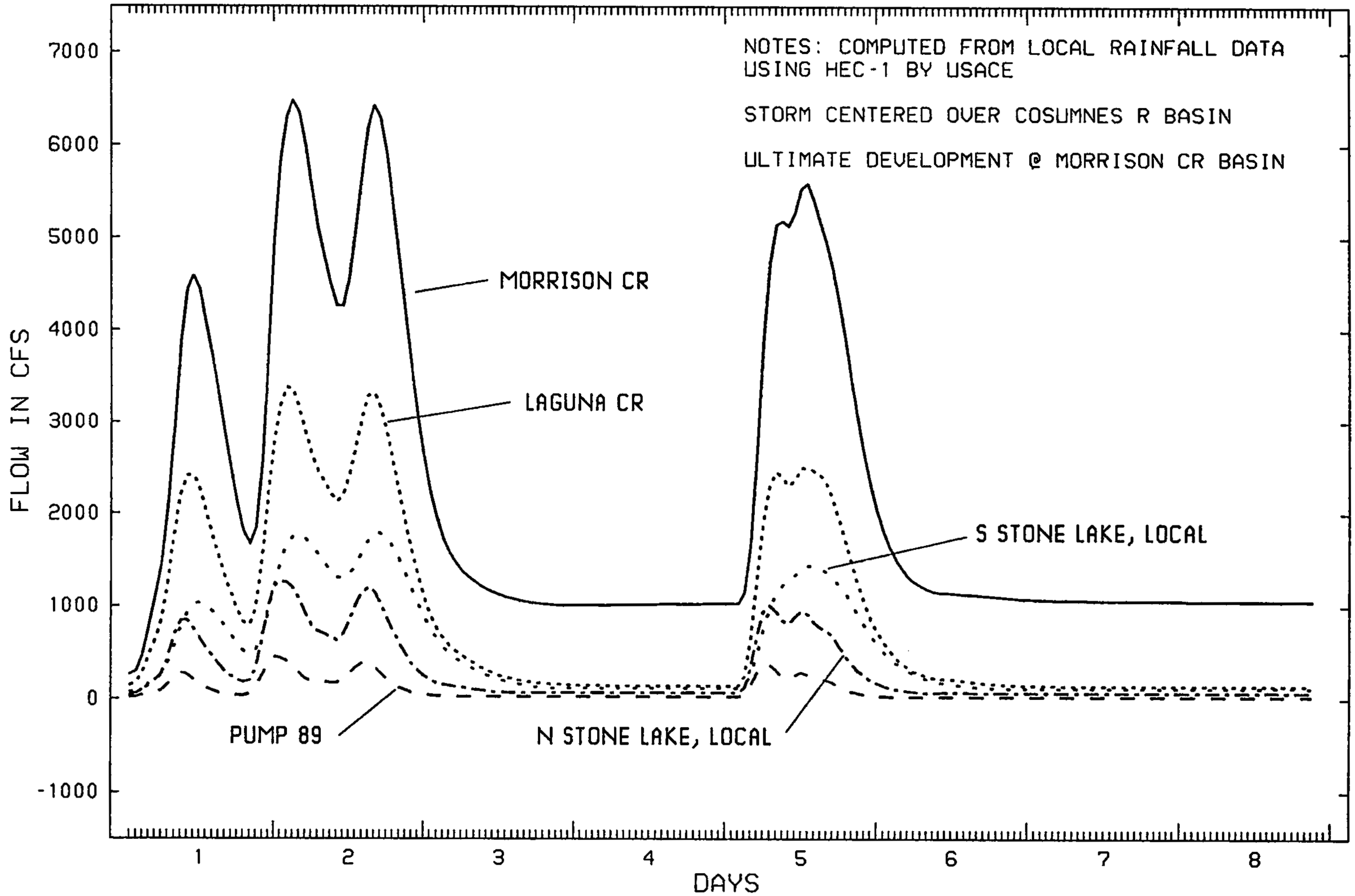
100-YEAR FLOOD
COMBINED INFLOW HYDROGRAPHS
MORRISON STREAM GROUP



DELTA MODELING SECTION OCT 90

FIGURE C-35

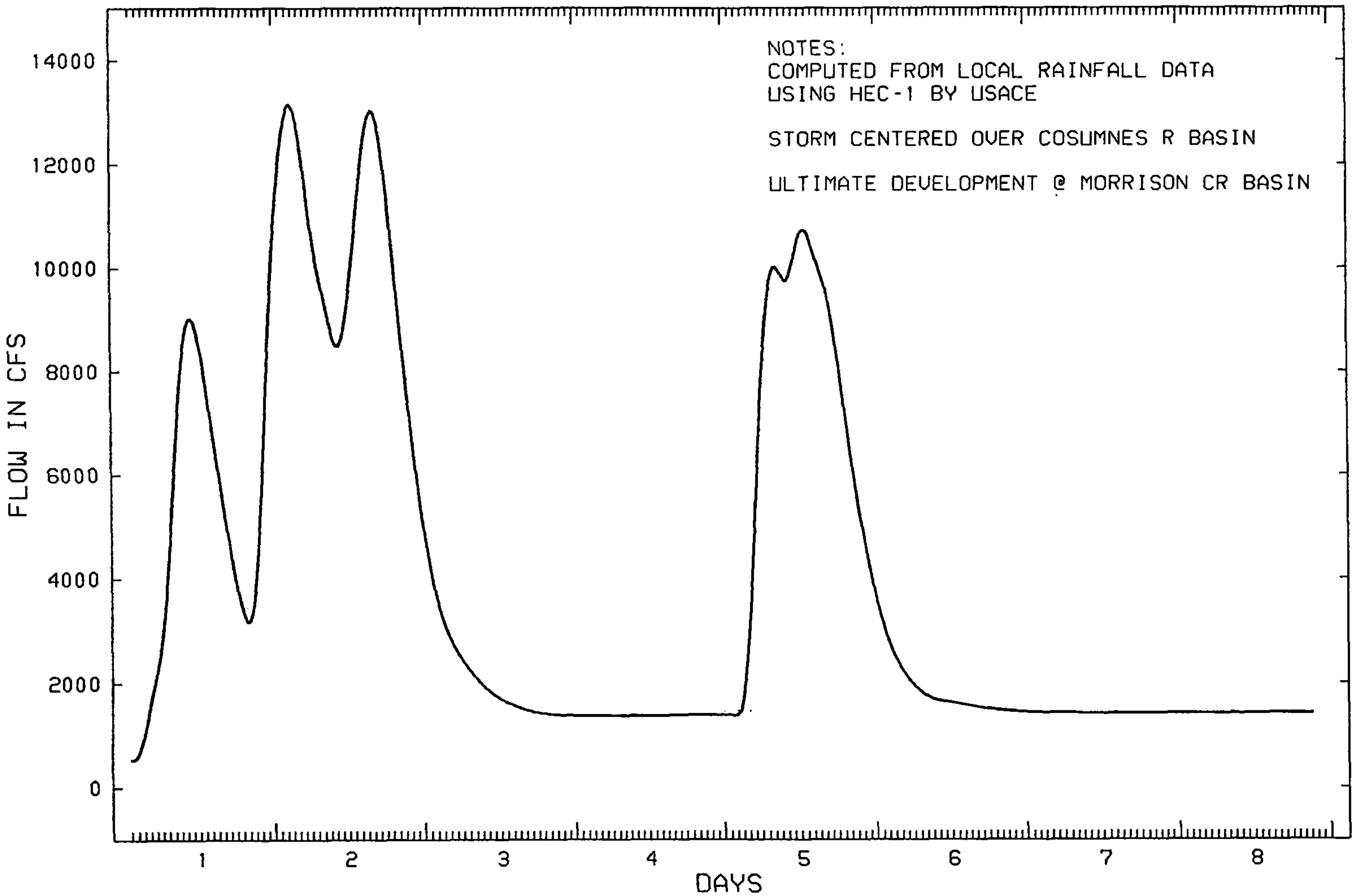
100-YEAR FLOOD
INFLOW HYDROGRAPHS
MORRISON STREAM GROUP



DELTA MODELING SECTION OCT 90

FIGURE C-36

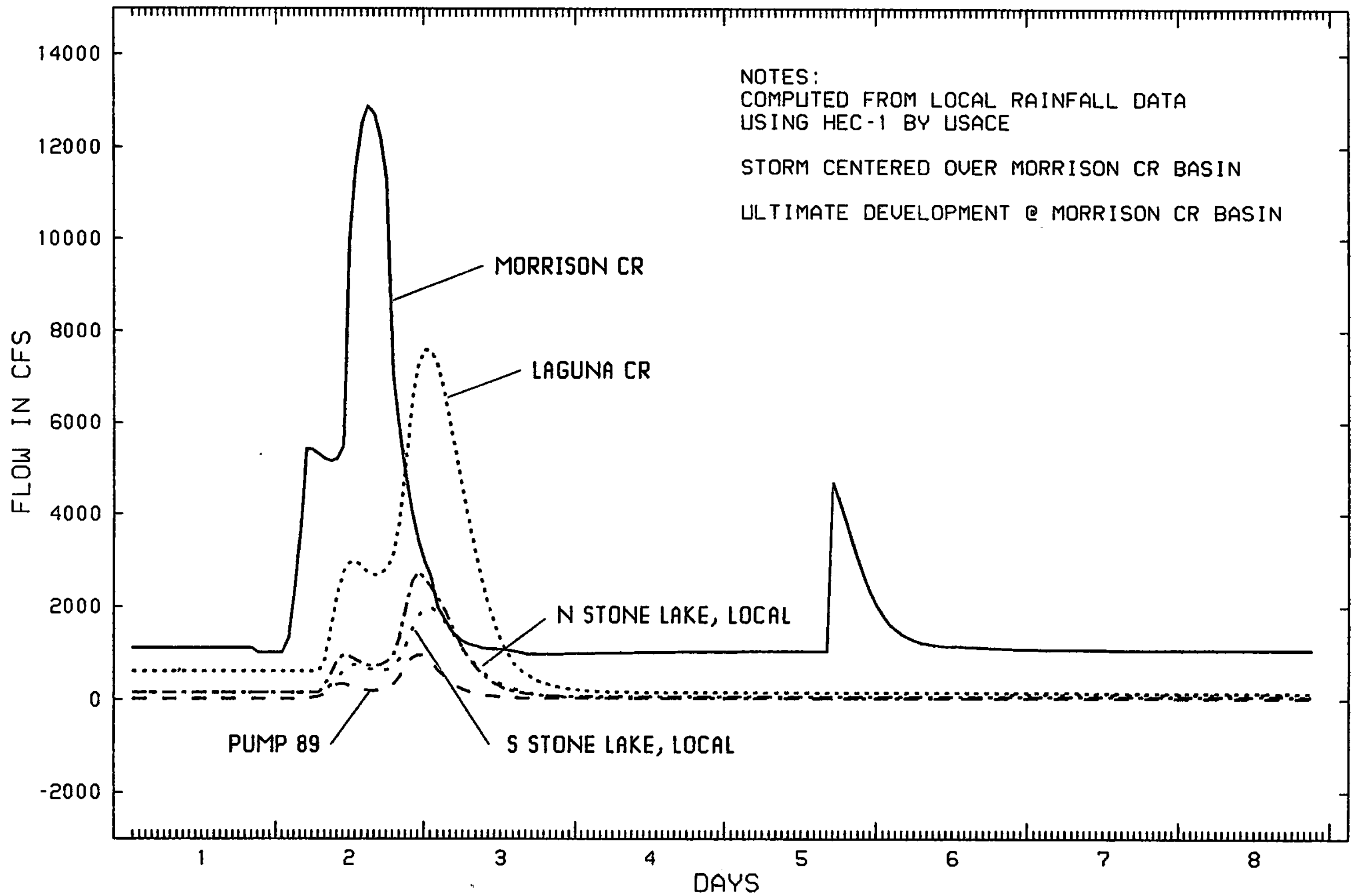
100-YEAR FLOOD
COMBINED INFLOW HYDROGRAPHS
MORRISON STREAM GROUP



DELTA MODELING SECTION OCT 90

FIGURE C-37

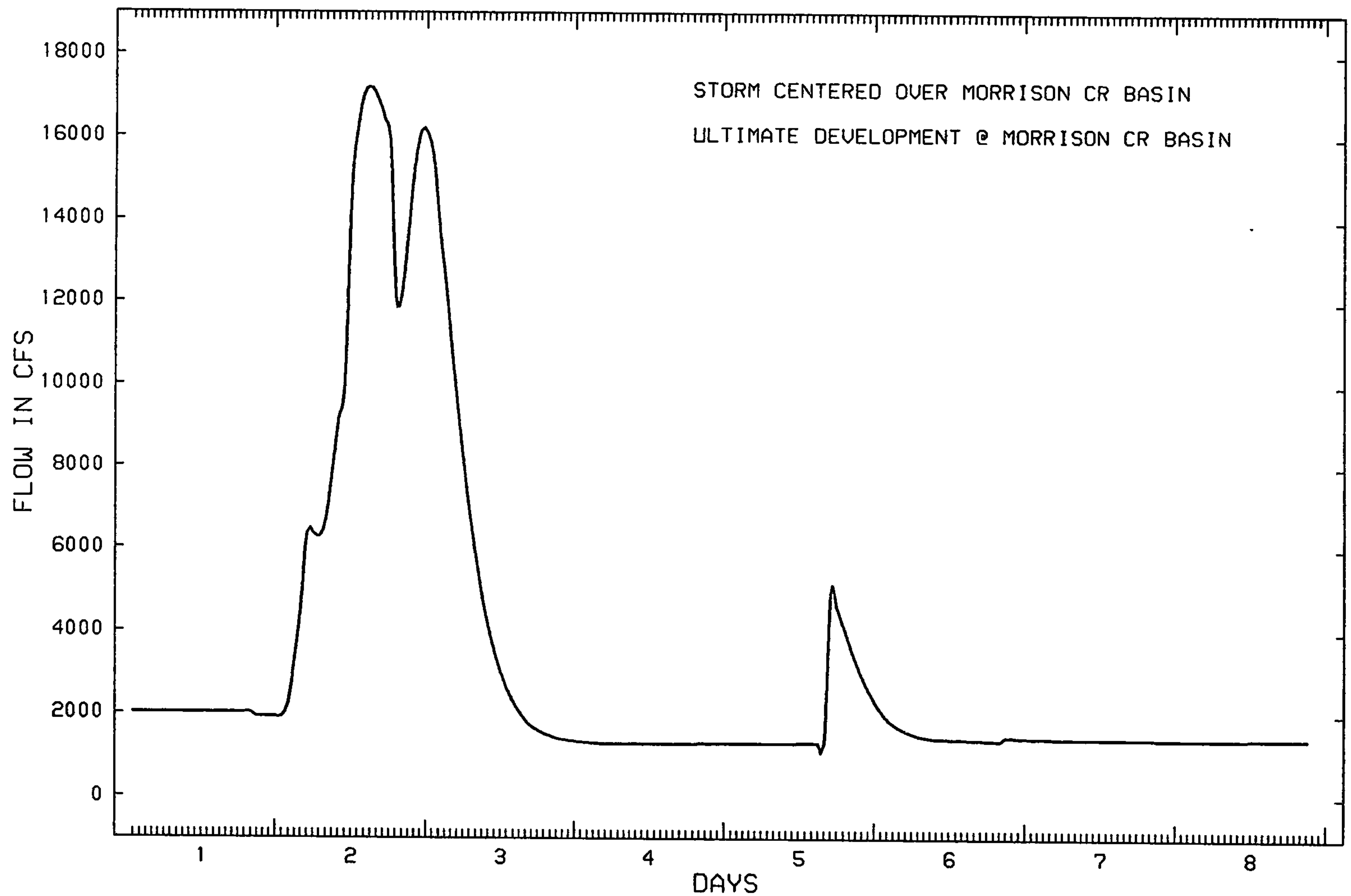
100-YEAR FLOOD INFLOW HYDROGRAPHS MORRISON STREAM GROUP



DELTA MODELING SECTION OCT 90

FIGURE C-38

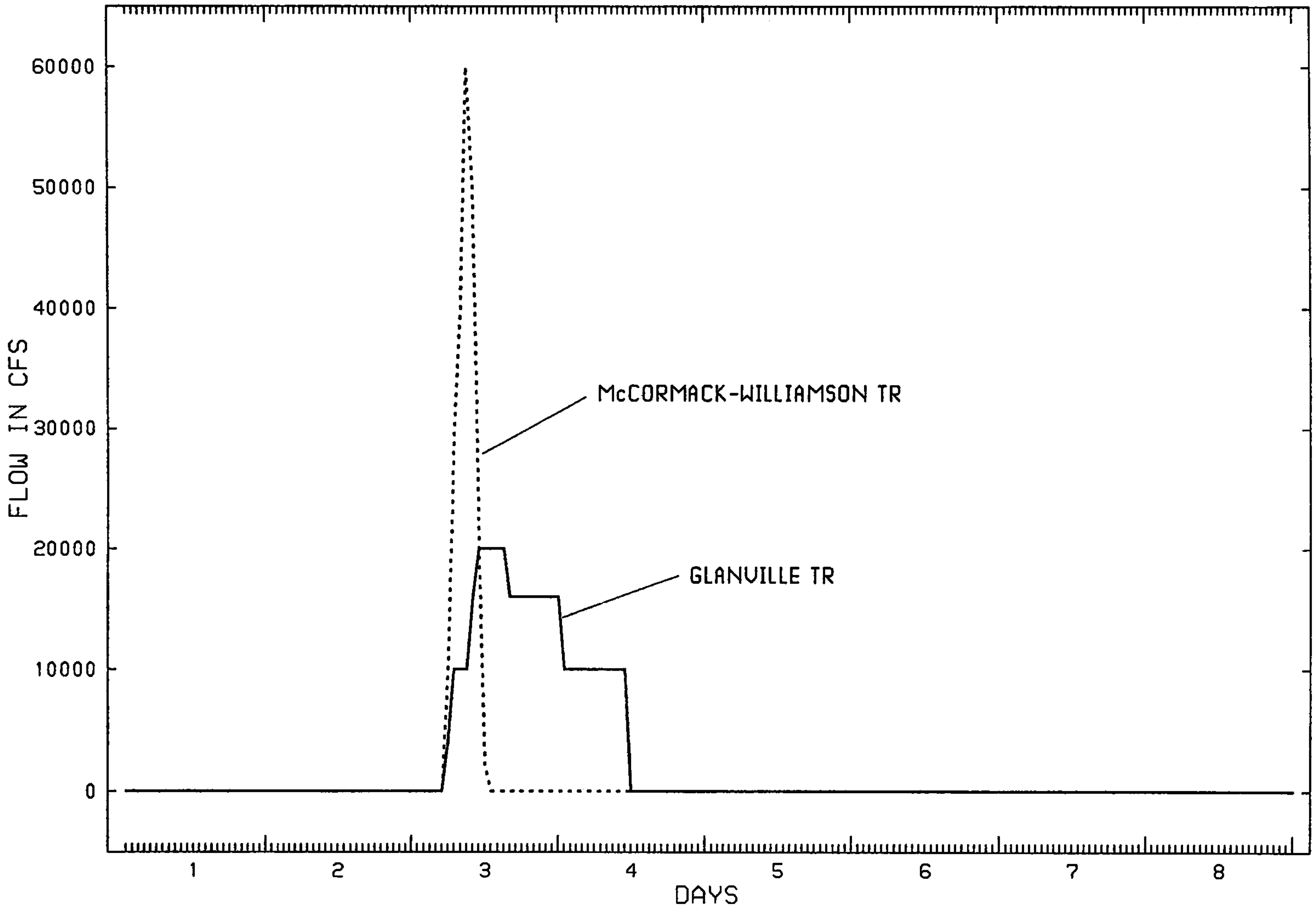
100-YEAR FLOOD
COMBINED INFLOW HYDROGRAPHS
MORRISON STREAM GROUP



DELTA MODELING SECTION OCT 90

FIGURE C-39

100-YEAR FLOOD
LEVEE BREACH HYDROGRAPHS

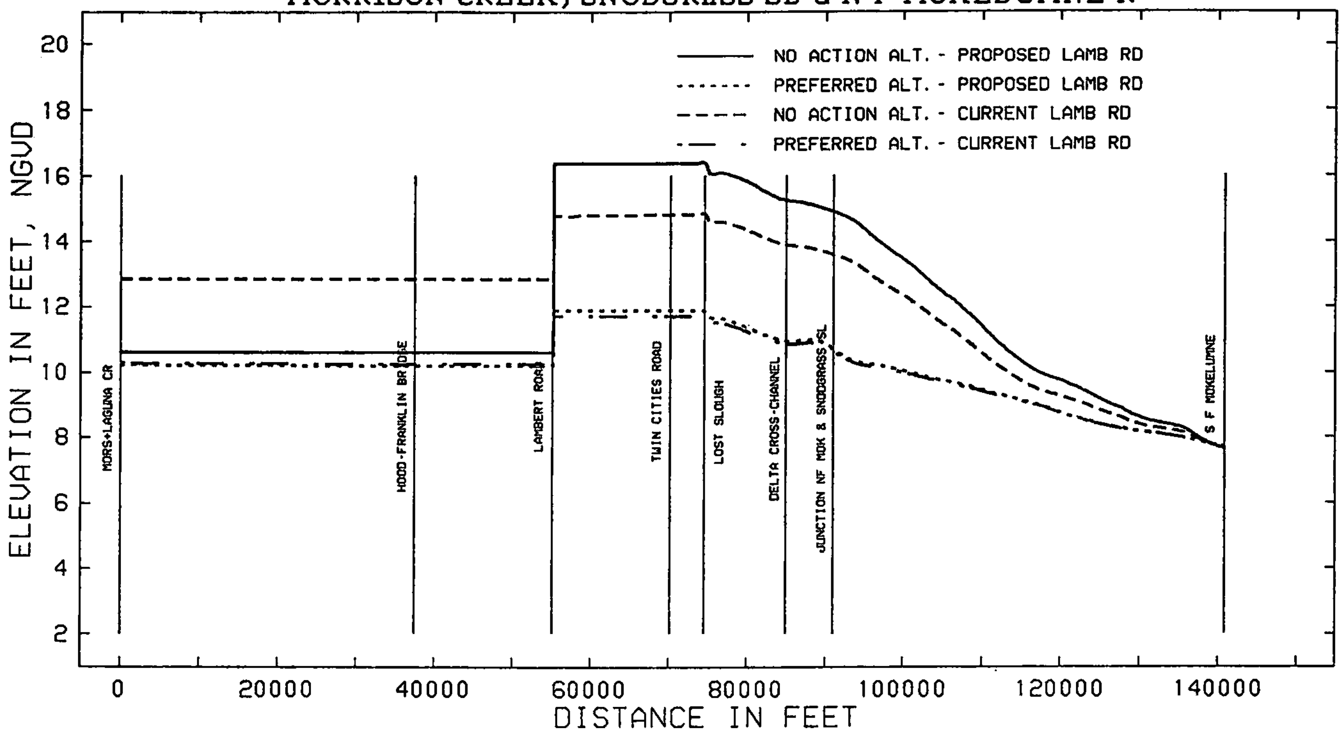


DELTA MODELING SECTION OCT 90

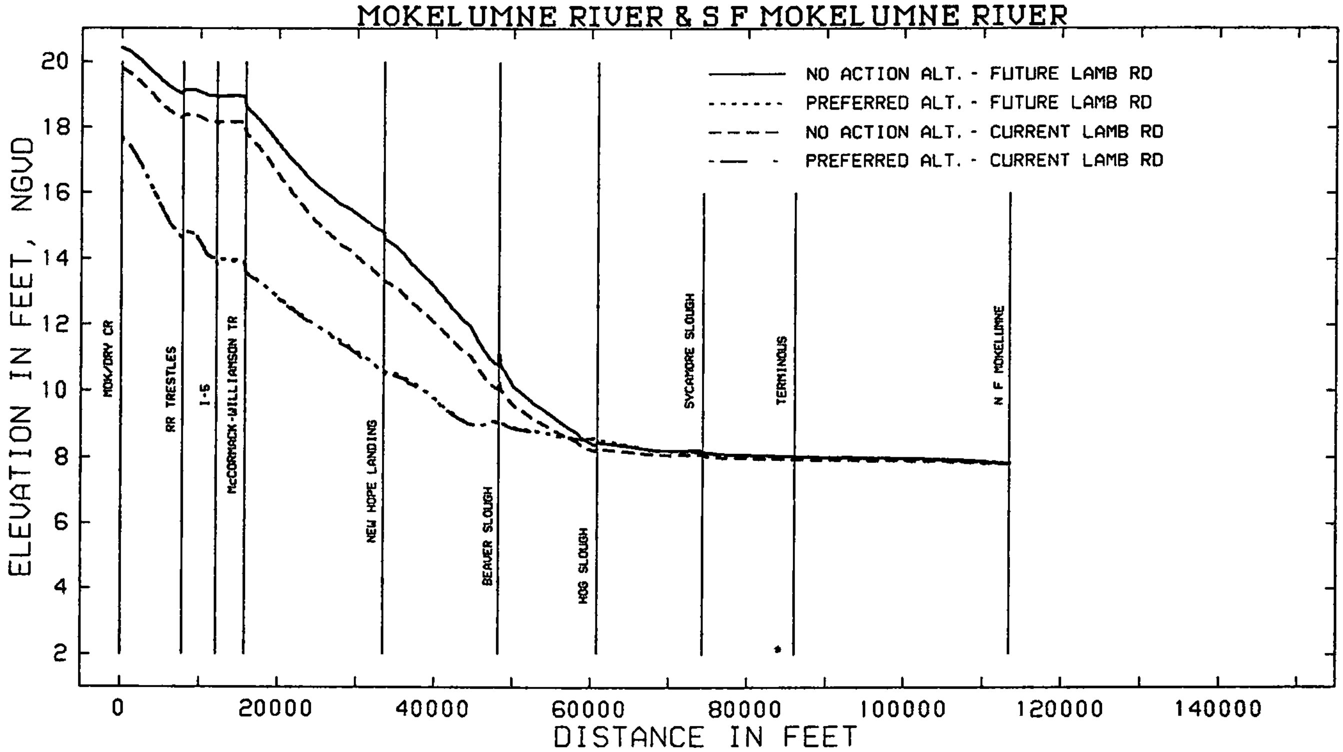
FIGURE C-40

100-YEAR FLOOD
MODEL SIMULATION RESULTS
McCORMACK-WILLIAMSON & GLANVILLE LEVEE BREAKS

WATER SURFACE PROFILE A
MORRISON CREEK, SNODGRASS SL & N F MOKELUMNE R



WATER SURFACE PROFILE B
MOKELUMNE RIVER & S F MOKELUMNE RIVER



DELTA MODELING SECTION OCT 90

FIGURE C-41

100-YEAR FLOOD
MODEL SIMULATION RESULTS
McCORMACK-WILLIAMSON & GLANVILLE LEVEE BREAKS, NO ACTION ALTERNATIVE,
CURRENT LAMBERT RD VS PREFERRED ALT, CURRENT LAMBERT RD
VELOCITY PROFILES AT DIFFERENT LOCATIONS

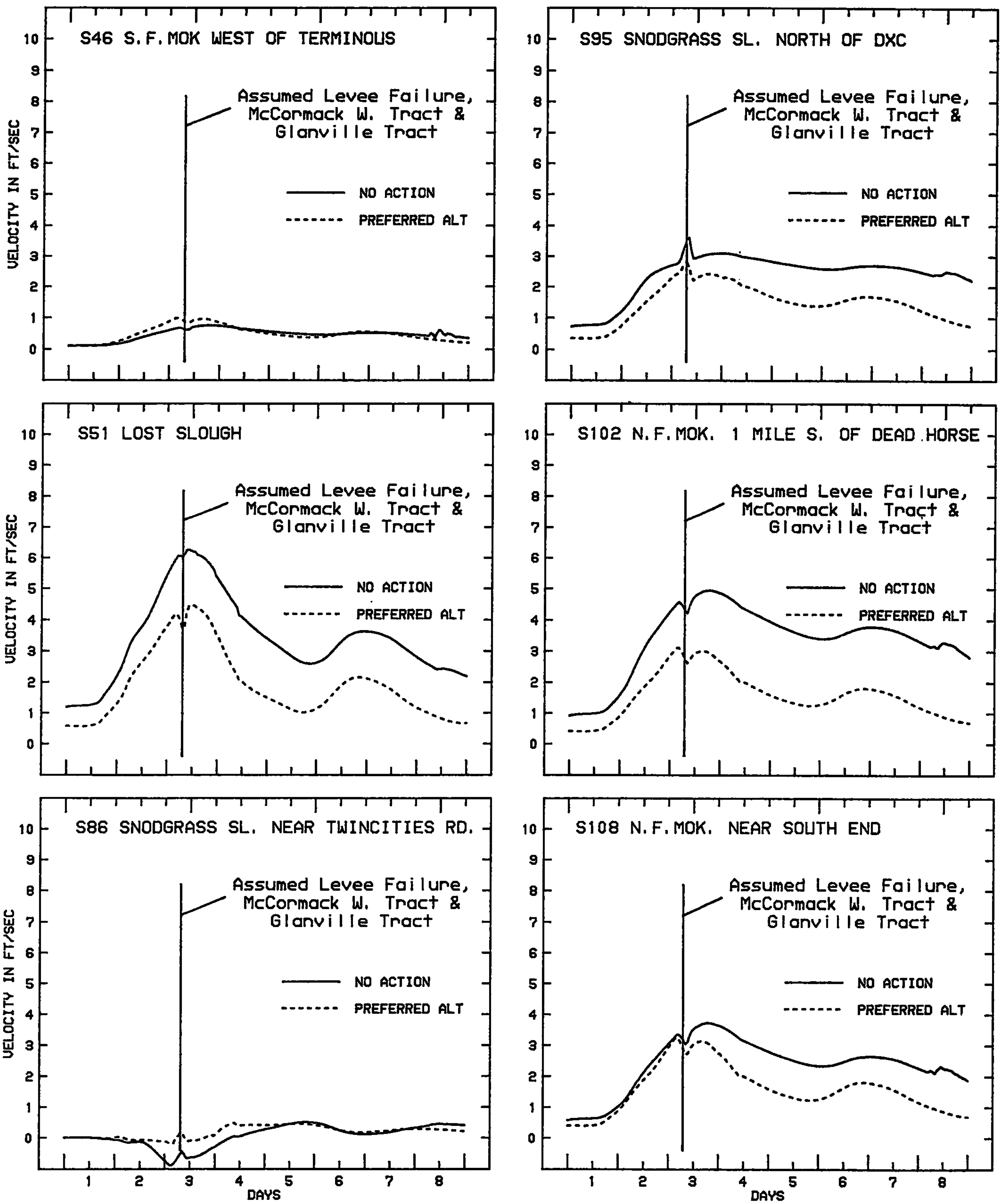
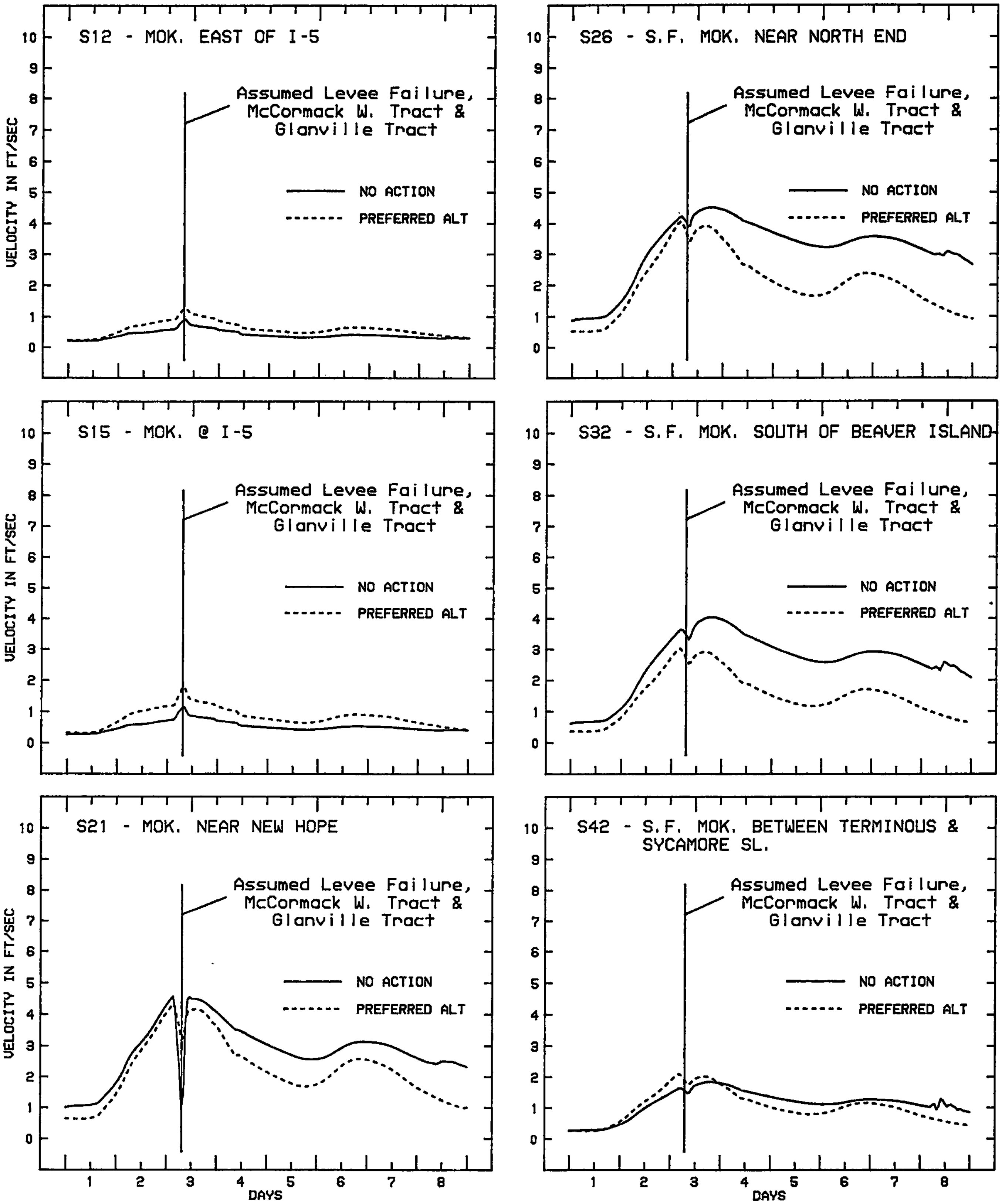


FIGURE C-41 (CON'T)

100-YEAR FLOOD
MODEL SIMULATION RESULTS
McCORMACK-WILLIAMSON & GLANVILLE LEVEE BREAKS, NO ACTION ALTERNATIVE,
CURRENT LAMBERT RD VS PREFERRED ALT, CURRENT LAMBERT RD
VELOCITY PROFILES AT DIFFERENT LOCATIONS



DELTA MODELING SECTION OCT 90

APPENDIX D
NORTH DELTA PROGRAM
BIOLOGICAL ASSESSMENT SUMMARY

APPENDIX D
NORTH DELTA PROGRAM
BIOLOGICAL ASSESSMENT SUMMARY

A biological assessment was completed by ECOS, Inc., to evaluate the impacts of the North Delta Program on threatened, endangered and candidate species. Their report, *Sensitive Species Survey Report for the North Delta Water Management Project,* was completed in July 1990.

The proposed actions evaluated in this biological assessment include the following:

- channel enlargement or dredging of north and south fork Mokelumne River,
- enlargement of the Delta Cross Channel gate structure, and
- creation of an island floodway from three north Delta islands: McCormack-Williamson Tract, Dead Horse island, and Staten Island.

The proposed actions have the potential to significantly affect several special status species. The fresh water marshes and swamps on instream islands and banks of project area waterways support:

- Suisun Marsh aster (federal candidate 2),
- Mason's *lilaeopsis* (federal candidate 2, State rare),
- California hibiscus (federal candidate 2),
- Delta tule pea (federal candidate 2), and
- Sanford's arrowhead (federal candidate 2).

The sensitive animal species documented in the project area include:

- greater sandhill crane (State threatened),
- California black rail (federal candidate 1, State threatened),
- Swainson's hawk (State threatened),
- giant garter snake (federal candidate 2, State threatened),
- western pond turtle (federal candidate 2),
- Winter-run Chinook salmon (federal threatened, State endangered).
- Sacramento splittail (federal candidate 2, California species of special concern), and
- Valley elderberry longhorn beetle (federal threatened).

The results of this assessment are summarized in Table 4-2 of Chapter 4 of the EIR/EIS.

Mitigation measures that will reduce impacts to these special status species to less than significant levels are discussed in the species accounts.

APPENDIX E
NDP ECONOMIC ANALYSIS

APPENDIX E
NDP ECONOMIC ANALYSIS SUMMARY

SUMMARY

Water supply and demand reduction alternatives examined in Appendix E are considered extraordinary and, in part represent the actions that would be needed to cover potential shortfalls in dependable supplies listed in DWR Bulletin 160–87, *California Water: Looking to the Future*, November 1987.

The procedure presented in Appendix E, and discussed briefly in Chapter 3, is the approach used for the South Coast Region M&I benefits.

Local water management program options were divided into three categories:

- shortage contingency demand management and supply enhancement options;
- long–term demand management and supply enhancement options; and
- risk management.

Shortage management contingency options are measures inplemented during shortages only and are intended to minimize the impacts of those shortages. Such measures include:

- use of banked local ground water;
- use of local carry–over storage;
- reduction of water deliveries to interruptible programs;
- purchasing water to augment normal sources of supply;
- instituting extraordinary water conservation measures; and
- rationing.

Long–term options considered include:

- waste water reclamation;
- desalination of brackish drainage and ground water;
- desalination of sea water; and
- development of water by importation.

Another long–term strategy evaluated in this analysis is the explicit evaluation of risk management with regard to the optimal level of use of long–term management options.

M&I economic benefits of the proposed North Delta Program were determined by using the Economic Risk Model for the South Coast Region to establish the effectiveness of local water management with and without the NDP in place. The increase in effectiveness was identified as NDP benefits for this region. Also, the agricultural benefit portion of the model was used to identify benefits to State Water Project agricultural contractors in Kings and Kern counties.

APPENDIX F
DIRECT FISH IMPACT ANALYSIS SUMMARY

APPENDIX F

DIRECT FISH IMPACT ANALYSIS SUMMARY

INTRODUCTION

DWR and DFG jointly developed the striped bass and salmon loss model (loss model) as a tool for calculating direct fishery losses as a function of monthly pumping rates at the State Water Project (SWP). For this model, loss is defined as those losses which occur from the time fish are drawn into Clifton Court Forebay until the survivors are returned to the Delta. This program is derived from a model originally developed by Alan Baracco of the California Department of Fish and Game (DFG) in 1984. Barry Collins (DFG) further refined this concept and described it in the "Agreement Between The Department Of Water Resources And The Department of Fish and Game To Offset Direct Fishery Losses To The Harvey O. Banks Delta Pumping Plant" (also known as "The Two Agency Fish or 4-Pumps Mitigation Agreement").

As used in the Two Agency Agreement, the model calculated the direct losses of striped bass, chinook salmon, and steelhead due to SWP pumping through the Banks Pumping Plant. For further details, background, and a listing of the striped bass and salmon survival factors used in this and the above models see "Estimates of Fish Entrainment Losses Associated with the State Water Project and Federal Central Valley Project Facilities in the South Delta" (DFG Exhibit 17 and DWR Exhibit 560 submitted to the SWRCB in Phase I of the Bay/Delta Hearing).

The Department of Water Resources has modified the model to allow user defined values for various parameters to be easily entered to calculate direct losses under various conditions. The model was also put into a machine language (Pascal) to increase computational efficiency.

The Loss Model Program

The loss model is a menu-driven program. The model calculates the following information for striped bass, chinook salmon, and steelhead trout over 20 millimeters (mm) long:

- the number of fish entering Clifton Court Forebay;
- the number of fish encountering the louvers;
- the screening efficiency factor for fish greater than 21 mm long;
- the number of fish released back into the Delta;
- the number of fish directly lost as a result of SWP operations;
- the number of fish lost if they had survived to reach one year of age, or a predetermined length (Yearling Equivalent Factor (YEF); and
- the optimum velocity and the number of bays to be used that allows for maximum fish salvage efficiency.

The striped bass eggs and the larvae under 20 mm long are considered nonsalvagable; therefore, they are counted as 100 percent direct loss. The numbers lost are based on an egg- and larvae-sampling program conducted outside the Clifton Court Forebay intake.

Both the input and output files require that the monthly data be divided into halves. The first half of the month corresponds to the first through the 15th day. The second half of the month is from the 16th to the end of that month.

The Input File

The input file must be a fixed-field ascii file, with at least two blank columns between fields of data (Table I). Once executed, the program lists all input data in the output file. In the following explanation of the input data, the numbers correspond to those in the column heads in Table I (pages 406–407).

1. **YEAR:** The year of record for the monthly salvage at the Skinner Facility.

2. **MO:** The month of record for the fish salvage.

3. **H:** The monthly fish salvage data must be divided into halves. **H** indicates the half of the month for which the data on that line is calculated.

4. **SWP Rate:** The SWP's average rate of pumping for the month. The program will accept either pumping rate (cfs) or volume pumped (acre-feet per month) and, regardless of input, will compute and list both in the output file. This value is calculated by averaging the daily mean pumping rates at the Bank's pumping plant. In the example file, average monthly pumping rates are input; it is assumed that the first and second monthly halves are similar. The loss calculations can be refined by entering the actual average pumping rate for the half-month interval rather than assuming equal rates (the mean pumping rate for the month) for both halves of the the month.

   Since Clifton Court Forebay came on line in 1971, exports have been taken from this forebay and not directly from Delta channels. The SWP rate must originate from the Bank's pumping plant rate and should not be confused with inflow into Clifton Court Forebay. The forebay inflow is needed to estimate the number of eggs and larvae entrained.

5. **LEN:** Average monthly length of fish. The screening efficiency depends on the length of fish. An overestimation in length would result in 1) an overestimate of the number of fish entering Clifton Court Forebay, the number encountering the screens, the number salvaged, the number released alive, and the screening efficiencies; and 2) an underestimate of the number lost through the screens, and mortalities from predation, trucking, and handling.

6. **SALV:** The bimonthly total of fish salvaged at the Skinner Facility. These values are monthly salvage totals divided into halves. DWR and DFG designed the fish salvage sampling process to provide an estimate of total fish salvaged for the day with an accuracy of 80% ± 50% if the daily total exceeds 10,000, and of 80% ± 100% if the daily total is less than 10,000 fish. (Anadromous Fisheries Branch Administrative Report No. 81-6, 1981). The screening efficiencies regression equations developed to estimate the monthly fish salvage have not been adjusted to account for modifications to the facility in 1984.

7–12. **EGGS AND LARVAE:** The number of striped bass eggs and the number of larvae lost (3-mm incremental length classes ranging from 3 to 20 mm);

   Since 1985, during the striped bass spawning period (May–July), DWR and DFG have been monitoring the striped bass eggs and larvae densities in the vicinity of the intake to Clifton Court Forebay. Based on the assumption that water drawn into the forebay contains the same mean densities of eggs and larvae as the water outside the forebay, these data are the basis for the entrainment values for this size group. The egg and larvae entrainment data entered into the input file to calculate 1979 through 1987 losses are the average of the actual field data collected in the 1985 and 1986 surveys. Work is underway to incorporate the 1987 and 1988 data into the average.

   All eggs and larvae drawn into the forebay are assumed lost. The loss model converts this loss into yearling equivalents in the same manner as for striped bass larger than 20 mm. The loss model lists the number of yearling equivalent striped bass under 20 mm lost under column 27 of the output file (Table II). This number is added to the total striped bass yearling equivalent loss in column 28 of the output file.

13. **LENC AND 15. LENSH:** The monthly average length of chinook salmon (column 13) and steelhead-trout (column 15) (see discussion on lengths above).

14. **SALVCS AND 16. SALVSH:** The bimonthly salvage totals for chinook salmon (column 14) and steelhead-trout (column 16).

The Output File

Output data for striped bass exceeding 21 mm long follow. In this explanation of the output file, the numbers correspond to those in Table II (pages 408–411).

1. **YEAR:** The year of record that the loss model used to estimate the fish losses.

2. **MO:** The month in which the fish salvage occurred.

3. **H:** Which half of the monthly data the model used.

4. **SWP VOL:** The volume of water pumped during that half of the month; the volume is for the number of days in each portion of the month, so the first and second half volumes may vary.

5. **SWP RATE:** The SWP's monthly rate of pumping.

6. **OPT VOL:** The optimum velocity is the optimum approach velocity required for maximum fish salvage efficiency. Approach velocity is defined as the mean velocity of the water in the channel approaching the fish screens. At the given pumping rate, the model determines the operation of the bays that will result in velocity closest to the optimum velocity possible. From November 1 through May 15, the loss model attempts to achieve 3.25 ft/s (optimum for salmon smolts) and from May 16 through October 31, the model attempts to achieve 1.00 ft/s when small striped bass are abundant near the intakes.

7. **OPT BAYS:** The optimum bays to be used for maximum fish salvage efficiency at the given pumping rate. These bays regulate the water approach velocity needed to maximize the fish screen efficiency. As pumping increases, additional bays become operational. As you face the Banks Pumping Plant, the bays are numbered from left to right.

   Since construction in 1968, bays 1 and 2 have been divided by a center wall and could operate independently of each other. Bays 3 and 4, each of which are equal in size to the total of bays 1 and 2, lacked a center wall. After 1982, the center wall was added, and each half of the bay was renamed. Bay 3 was renamed bays 3a and 3b, and bay 4 was renamed bays 4a and 4b. Bay 5, which is the same size as bay 1, remained the same.

   Prior to installation of the center walls, both screens in each bay had to be operated in conjunction with one another since there was no way to alter the approach velocity in front of one screen and not affect the approach velocity of the facing screen in the same bay. DFG found that although the bays possessing the center wall are more efficient for most fish species, it was not true for salmon. However, the differences in efficiency are believed to be minimal. Neither effects of the the joint operations of these bays nor installation of the center wall are addressed in the model or in any adjustment of the data. The loss model establishes the optimum bay's selection solely on cross-sectional area needed to maintain the optimum approach velocity towards the fish screens.

8. **SFF VEL:** The water velocity flowing through the bays. **SFF VEL** is not the actual channel velocity. It is a value calculated by the model using the SWP's monthly average pumping rate and dividing it by the optimum channel width (numbers of bays times the cross-sectional area of each bay) for that pumping rate. The **SFF VEL** is a calculated velocity, which is the closest the Skinner Facility could get to the optimum velocity with the given operating criteria.

9. **LENG SB:** Average monthly length of striped bass. The loss model obtains this data from the input file and list it in the output file. See discussion of this factor under the input data.

10. **EFF SB:** The screening efficiency factor for striped bass. The program uses this value to estimate the number of fish that encounter the salvage screens (column 12). The loss model bases the screening efficiency factor on both the length of the fish salvaged, and the water velocity through the screens using regressions. Boracco (DFG) developed these equations from data collected during field tests performed in 1973. These regressions do not reflect the modifications to the Skinner Facility completed in 1984. Monthly fish salvage totals since 1984 suggest that the screening efficiencies have increased. If true, the loss model underestimates these efficiencies.

    Screening efficiencies are important in estimating the number of fish salvaged. The fish salvage is used to calculate all other parameters used to determine the direct fish losses. Underestimations of screening efficiencies leads to: 1) underestimates in both the fish salvaged and the number released alive; and 2) overestimates in the number of fish and yearling equivalents lost, the number of fish encountering the screens, the number of fish entering the forebay, and the number of fish lost by predation, trucking and hauling.

11. **SALV SB:** The listing of the striped bass's monthly salvage from the input file. (See Input File # 6.)

12. **ENCOUNT SCREENS**: The number of striped bass estimated to have encountered the salvage screens. The loss model computes the number of fish encountering the screens as the number of fish salvaged, divided by the screening efficiency.

13. **MORT PRED:** The mortality factor due to predation (P). All losses occurring in Clifton Court Forebay are attributed to predation. This value is: 1–P = number of fish encountering the screens divided by the number of fish entrained into the forebay.

    The predation factor used to calculate the number of fish entering the forebay (column 14). The model permits the user to change the predation rate prior to program execution.

    The loss model reads all mortality rates (predation, trucking, and handling) from a data file (**MORT. DAT**) into a matrix, then determines the mortality based on the average monthly fish lengths.

14. **ENTERCCF SB:** The number of striped bass entering (entrained) Clifton Court Forebay. All fish entering the forebay are considered entrained. The loss model estimates the number of fish entrained by dividing the number of fish encountering the screens.

15. **MORT HAND:** The percentage of fish that die due to handling during the salvage process. As with the mortality due to predation, the program allows the user to change these values prior to execution. The program list these mortality rates that it uses to estimate the number of fish released alive into the Delta.

16. **MORT TRUCK:** The percentage of fish that die from being trucked back to the Delta.

17. **ALIVE SB:** The number of fish released alive back into the Delta. The loss model multiplies the number of fish in the monthly salvage by the survival factors related to the handling and trucking process.

    The number of fish released alive does not address the possibility that some fish released alive may die soon afterwards from the stress of the entrainment process. These stresses include predation, temperature extremes, and disorientation upon release. The entrainment stresses may also weaken fish and decrease their resistance to natural stresses that they normally would have survived.

18. **LOSS SB**: The number of striped bass directly lost due to SWP operations. The loss model computes this as the number of bass entering the forebay subtracted by the number of bass released alive. The loss model uses this value to estimate the number of yearling equivalents lost .

19. **YEF SB**: The yearling equivalent factor for striped bass. The program reads this factor from a data file (**YEFSB.DAT**) into an array, then determines the appropriate value based on the month (first or second half), and the average length. The data base available for the striped bass is semimonthly whereas the chinook and steelhead data are available only on a monthly basis. The program lists the factor used to compute the yearling equivalent loss in this column. The model assumes that the yearling equivalent factor for salmon and steelhead is identical (columns 39 and 50).

20. **LOSSYE SBGE21:** The loss of yearling equivalent striped bass greater than 20 mm long. The model computes this sum as the system loss (column 18) multiplied by the yearling equivalent factor (column 19).

Eggs and Larvae

21–26. EGGS, AND LARVAE LENGTH CLASSES: The number of striped bass eggs and larvae in each of the incremented 3-mm length classes. The model obtains these values from the input file and lists them in the output. Since all eggs and larvae entrained are assumed lost, the program directly converts these losses into yearling equivalents (column 27) in the same manner as bass larger than 20 mm discussed above.

27. LOSSYE SBLT21: The loss of yearling equivalent bass less than 21 mm long. The model estimates this value as the number of eggs and larvae entrained (columns 21–16) multiplied by the appropriate yearling equivalent factor.

The Total Yearling Equivalent Loss

28. **LOSS YESB:** The total yearling equivalent loss of striped bass. The model estimates this value as the sum of the yearling equivalent loss of striped bass under 21 mm, plus those yearling equivalents over 21 mm.

Chinook Salmon and Steelhead Output

The loss model computes the output for chinook salmon and steelhead in the same manner as the striped bass. The loss model assumes that the screening efficiency, the mortalities (predation, trucking, and handling), and the yearling equivalent factors for salmon and steelhead are identical. For details of the output, see the appropriate column for striped bass above.

29. LENG CS and 41. LENG SH: The average monthly length of chinook salmon (column 29) and steelhead trout (column 41).

30. EFF CS: The screening efficiency of chinook salmon and steelhead trout. During the first half of May, the optimum velocity is set at 3.5 ft/s for chinook salmon. In the second half of May the optimum velocity is dropped to 1 ft/s for striped bass. This is reflected in the mid-month change in yearling equivalent salmon losses in May. (See **EFF SB,** #10 above.).

31. SALV CS and 43. SALV SH: The monthly salvage for salmon (column 31) and steelhead (column 43) for that half of the month (see striped bass salvage—column 11 above.)

32 and 44. ENCOUT SCREEN: The estimated number of salmon (column 32) and steelhead (column 44) encountering the salvage screens. (See **ENTERCCF SB,** #14, above.)

33. PRED CS: The mortality factor due to predation for both salmon and steelhead. (See **MORT PRED,** #13 above.)

34 and 46. ENTER CCF: The estimated number of salmon and steelhead trout (column 46) entering Clifton Court Forebay. (See **ENTERCCF SB,** #14, above.)

35. MORT HAND and 36 MORT TRUCK: The mortality factor due to handling (column 35) and trucking (column 36) for salmon and steelhead. (See **MORT HAND,** #15, **and MORT TRUCK,** #16, above).

37. ALIVE CS and 49. ALIVE SH: The number of salmon (column 37) and steelhead (column 49) released alive. (See **ALIVE SB,** #17 above).

38. LOSS CS and 5.0 LOSS SH: The estimated total loss for salmon (column 38) and steelhead (column 50). (See **LOSS SB,** #18 above.)

39. YEF CS and 51. YEF SH: The yearling equivalent loss factor used to calculate yearling equivalent losses for both steelhead and salmon. This data is available only on a monthly basis for chinook salmon and steelhead. (See **YEF SB,** #19 above.)

40. LOSSYE CS and 52. LOSSYE SH: The yearling equivalent losses for salmon (column 40) and steelhead (column 52). See **LOSSYE SBGE 21,** #28 above.)

TABLE I. Illustration of the data columns in the loss model input file.

(1) YEAR	(2) MO	(3) HA	(4) SWPRate	(5) LENSB	(6) SALVSB	(7) EGGSSB	(8) 3ot6mmSB	(9) 7to10mmSB
1979	1	1	1313.	87.	17234.	0.	0.	0.
1979	1	2	1313.	87.	17234.	0.	0.	0.
1979	2	1	1626.	85.	4059.	0.	0.	0.
1979	2	2	1626.	85.	4059.	0.	0.	0.
1979	3	1	2333.	93.	304.	0.	0.	0.
1979	3	2	2333.	93.	304.	0.	0.	0.
1979	4	1	2645.	139.	298.	0.	0.	0.
1979	4	2	2645.	139.	298.	1696674.	19231000.	2144614.
1979	5	1	3000.	82.	6283.	37840000.	37015000.	7495317.
1979	5	2	3000.	82.	6283.	4861228.	76667000.	4153197.
1979	6	1	3001.	29.	432355.	427201.	22036000.	7500488.
1979	6	2	3001.	29.	432355.	0.	11587000.	7570838.
1979	7	1	4593.	42.	571865.	0.	613418.	693817.
1979	7	2	4593.	42.	571865.	0.	0.	0.
1979	8	1	5635.	65.	161376.	0.	0.	0.
1979	8	2	5635.	65.	161376.	0.	0.	0.
1979	9	1	4666.	102.	5465.	0.	0.	0.
1979	9	2	4666.	102.	5465.	0.	0.	0.
1979	10	1	3634.	89.	23732.	0.	0.	0.
1979	10	2	3634.	89.	23732.	0.	0.	0.
1979	11	1	4735.	93.	60051.	0.	0.	0.
1979	11	2	4735.	93.	60051.	0.	0.	0.
1979	12	1	5859.	102.	73383.	0.	0.	0.
1979	12	2	5859.	102.	73383.	0.	0.	0.

(TABLE I continued)

(10) 11to14mmSB	(11) 15to18mmSB	(12) 19to20mmSB	(13) LENCS	(14) SALVCS	(15) LENSH	(16) SALVSH
0.	0.	0.	190.	1199.	347.	8.
0.	0.	0.	190.	1199.	347.	8.
0.	0.	0.	194.	593.	285.	12.
0.	0.	0.	194.	593.	285.	12.
0.	0.	0.	185.	1151.	395.	226.
0.	0.	0.	185.	1151.	395.	226.
0.	0.	0.	122.	14496.	384.	505.
0.	0.	0.	122.	14496.	384.	505.
0.	0.	0.	93.	29894.	364.	485.
479746.	0.	0.	93.	29894.	364.	485.
1919741.	347552.	0.	92.	4768.	0.	0.
1025524.	0.	0.	92.	4768.	0.	0.
950834.	94153.	176826.	70.	2823.	0.	0.
0.	0.	0.	70.	2823.	0.	0.
0.	0.	0.	102.	180.	0.	0.
0.	0.	0.	102.	180.	0.	0.
0.	0.	0.	126.	35.	0.	0.
0.	0.	0.	126.	35.	0.	0.
0.	0.	0.	183.	759.	0.	0.
0.	0.	0.	183.	759.	0.	0.
0.	0.	0.	154.	2696.	474.	10.
0.	0.	0.	154.	2696.	474.	10.
0.	0.	0.	161.	2625.	0.	12.
0.	0.	0.	161.	2625.	0.	12.

TABLE II. Description of data columns in the loss model output file.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
YEAR	MO	H	SWP VOL	SWP RATE	OPT VEL	OPT BAYS	SFF VEL	LENG SB	EFF SB	SALV SB	ENCOUNT SCREENS	MORT PRED	ENTERCCF SB	MORT HAND	MORT TRUCK	ALIVE SB
1979	1	1	39065	1313	3.25	1	3.13	87	0.72	17234	23908	0.29	33673	0.06	0.03	15714
1979	1	2	41669	1313	3.25	1	3.13	87	0.72	17234	23908	0.29	33673	0.06	0.03	15714
1979	2	1	48378	1626	3.25	1	3.87	85	0.67	4059	6082	0.29	8566	0.06	0.03	3701
1979	2	2	41927	1626	3.25	1	3.87	85	0.67	4059	6082	0.29	8566	0.06	0.03	3701
1979	3	1	69413	2333	3.25	12	2.78	93	0.75	304	408	0.23	529	0.01	0.00	301
1979	3	2	74040	2333	3.25	12	2.78	93	0.75	304	408	0.23	529	0.01	0.00	301
1979	4	1	78695	2645	3.25	12	3.15	139	0.72	298	414	0.06	441	0.00	0.00	298
1979	4	2	78695	2645	3.25	12	3.15	139	0.72	298	414	0.06	441	0.00	0.00	298
1979	5	1	89257	3000	3.25	3	3.49	82	0.69	6283	9042	0.29	12735	0.06	0.03	5729
1979	5	2	95208	3000	1.00	12345	1.01	82	0.87	6283	7199	0.29	10139	0.06	0.03	5729
1979	6	1	89287	3001	1.00	12345	1.01	29	0.78	432355	550806	0.83	3240034	0.35	0.31	193911
1979	6	2	89287	3001	1.00	12345	1.01	29	0.78	432355	550806	0.83	3240034	0.35	0.31	193911
1979	7	1	136653	4593	1.00	12345	1.54	42	0.83	571865	685286	0.60	1713216	0.26	0.23	325849
1979	7	2	145763	4593	1.00	12345	1.54	42	0.83	571865	685286	0.60	1713216	0.26	0.23	325849
1979	8	1	167655	5635	1.00	12345	1.89	65	0.81	161376	199372	0.42	343746	0.16	0.13	117934
1979	8	2	178832	5635	1.00	12345	1.89	65	0.81	161376	199372	0.42	343746	0.16	0.13	117934
1979	9	1	138825	4666	1.00	12345	1.57	102	0.83	5465	6563	0.18	8003	0.00	0.00	5465
1979	9	2	138825	4666	1.00	12345	1.57	102	0.83	5465	6563	0.18	8003	0.00	0.00	5465
1979	10	1	108121	3634	1.00	12345	1.22	89	0.86	23732	27674	0.29	38977	0.06	0.03	21639
1979	10	2	115329	3634	1.00	12345	1.22	89	0.86	23732	27674	0.29	38977	0.06	0.03	21639
1979	11	1	140878	4735	3.25	13	3.70	93	0.68	60051	88341	0.23	114728	0.01	0.00	59450
1979	11	2	140878	4735	3.25	13	3.70	93	0.68	60051	88341	0.23	114728	0.01	0.00	59450
1979	12	1	174320	5859	3.25	34	3.41	102	0.70	73383	104719	0.18	127706	0.00	0.00	73383
1979	12	2	185941	5859	3.25	34	3.41	102	0.70	73383	104719	0.18	127706	0.00	0.00	73383

(TABLE II continued)

(18) LOSS SB	(19) YEF SB	(20) LOSSYE SBGE21	(21) EGGS	(22) SB 3-6	(23) SB 7-10	(24) SB 11-14	(25) SB 15-18	(26) SB 19-20	(27) LOSSYE SBLT21	(28) LOSS YESB
17959	0.63694	11439	0	0	0	0	0	0	0	11439
17959	0.69581	12496	0	0	0	0	0	0	0	12496
4865	0.77718	3781	0	0	0	0	0	0	0	3781
4865	0.88158	4289	0	0	0	0	0	0	0	4289
228	1.00000	228	0	0	0	0	0	0	0	228
228	1.00000	228	0	0	0	0	0	0	0	228
143	1.00000	143	0	0	0	0	0	0	0	143
143	1.00000	143	1696674	19231000	2144614	0	0	0	3189	3332
7006	1.00000	7006	37840000	37015000	7495317	0	0	0	8902	15908
4410	1.00000	4410	4861228	76667000	4153197	479746	0	0	12343	16753
3046123	0.00624	19020	427201	22036000	7500488	1919741	347552	0	12334	31354
3046123	0.00648	19754	0	11587000	7570838	1025524	0	0	6569	26323
1387367	0.04625	64171	0	613418	693817	950834	94153	176826	6910	71081
1387367	0.04804	66649	0	0	0	0	0	0	0	66649
225812	0.18710	42249	0	0	0	0	0	0	0	42249
225812	0.19432	43880	0	0	0	0	0	0	0	43880
2538	0.62406	1584	0	0	0	0	0	0	0	1584
2538	0.63974	1624	0	0	0	0	0	0	0	1624
17338	0.44693	7749	0	0	0	0	0	0	0	7749
17338	0.46419	8048	0	0	0	0	0	0	0	8048
55278	0.59944	33136	0	0	0	0	0	0	0	33136
55278	0.62259	34416	0	0	0	0	0	0	0	34416
54323	0.74330	40378	0	0	0	0	0	0	0	40378
54323	0.77200	41938	0	0	0	0	0	0	0	41938

(TABLE II continued)

(29) LENG CS	(30) EFF CS	(31) SALV CS	(32) ENCOUNT SCREEN	(33) PRED CS	(34) ENTER CCF	(35) MORT HAND	(36) MORT TRUCK	(37) ALIVE CS	(38) LOSS CS	(39) YEF CS	(40) LOSSYE CS	(41) LENG CS
190	0.75	1199	1601	0.75	6403	0.00	0.00	1199	5204	1.0000	5204	347
190	0.75	1199	1601	0.75	6403	0.00	0.00	1199	5204	1.0000	5204	347
194	0.79	593	749	0.75	2994	0.00	0.00	593	2401	1.0000	2401	285
194	0.79	593	749	0.75	2994	0.00	0.00	593	2401	1.0000	2401	285
185	0.73	1151	1579	0.75	6317	0.00	0.00	1151	5166	1.0000	5166	395
185	0.73	1151	1579	0.75	6317	0.00	0.00	1151	5166	1.0000	5166	395
122	0.75	14496	19320	0.75	77279	0.00	0.00	14496	62783	1.0000	62783	384
122	0.75	14496	19320	0.75	77279	0.00	0.00	14496	62783	1.0000	62783	384
93	0.80	29894	37259	0.75	149037	0.02	0.00	29296	119741	0.3200	38317	364
93	0.68	29894	43979	0.75	175917	0.02	0.00	29296	146620	0.3200	46919	364
92	0.68	4768	7014	0.75	28057	0.02	0.00	4673	23385	0.3200	7483	0
92	0.68	4768	7014	0.75	28057	0.02	0.00	4673	23385	0.3200	7483	0
70	0.71	2823	3998	0.75	15991	0.02	0.00	2767	13225	0.3200	4232	0
70	0.71	2823	3998	0.75	15991	0.02	0.00	2767	13225	0.3200	4232	0
102	0.68	180	266	0.75	1063	0.00	0.00	180	883	1.0000	883	0
102	0.68	180	266	0.75	1063	0.00	0.00	180	883	1.0000	883	0
126	0.66	35	53	0.75	213	0.00	0.00	35	178	1.0000	178	0
126	0.66	35	53	0.75	213	0.00	0.00	35	178	1.0000	178	0
183	0.64	759	1189	0.75	4754	0.00	0.00	759	3995	1.0000	3995	0
183	0.64	759	1189	0.75	4754	0.00	0.00	759	3995	1.0000	3995	0
154	0.78	2696	3447	0.75	13787	0.00	0.00	2696	11091	1.0000	11091	474
154	0.78	2696	3447	0.75	13787	0.00	0.00	2696	11091	1.0000	11091	474
161	0.77	2625	3430	0.75	13721	0.00	0.00	2625	11096	1.0000	11096	0
161	0.77	2625	3430	0.75	13721	0.00	0.00	2625	11096	1.0000	11096	0

(TABLE II continued)

(42) EFF SH	(43) SALV SH	(44) ENCOUNT SCREEN	(45) PRED SH	(46) ENTER CCF	(47) MORT HAND	(48) MORT TRUCK	(49) ALIVE SH	(50) LOSS SH	(51) YEF SH	(52) LOSSYE SH
0.75	8	11	0.75	43	0.00	0.00	8	35	1.0000	35
0.75	8	11	0.75	43	0.00	0.00	8	35	1.0000	35
0.79	12	15	0.75	61	0.00	0.00	12	49	1.0000	49
0.79	12	15	0.75	61	0.00	0.00	12	49	1.0000	49
0.73	226	310	0.75	1240	0.00	0.00	226	1014	1.0000	1014
0.73	226	310	0.75	1240	0.00	0.00	226	1014	1.0000	1014
0.75	505	673	0.75	2692	0.00	0.00	505	2187	1.0000	2187
0.75	505	673	0.75	2692	0.00	0.00	505	2187	1.0000	2187
0.77	485	630	0.75	2520	0.00	0.00	485	2035	1.0000	2035
0.63	485	774	0.75	3098	0.00	0.00	485	2613	1.0000	2613
0.68	0	0	0.75	0	0.02	0.00	0	0	0.8727	0
0.68	0	0	0.75	0	0.02	0.00	0	0	0.8727	0
0.71	0	0	0.75	0	0.02	0.00	0	0	0.8727	0
0.71	0	0	0.75	0	0.02	0.00	0	0	0.8727	0
0.72	0	0	0.75	0	0.02	0.00	0	0	0.8727	0
0.72	0	0	0.75	0	0.02	0.00	0	0	0.8727	0
0.71	0	0	0.75	0	0.02	0.00	0	0	0.8727	0
0.71	0	0	0.75	0	0.02	0.00	0	0	0.8727	0
0.69	0	0	0.75	0	0.02	0.00	0	0	0.8727	0
0.69	0	0	0.75	0	0.02	0.00	0	0	0.8727	0
0.78	10	13	0.75	51	0.00	0.00	10	41	1.0000	41
0.78	10	13	0.75	51	0.00	0.00	10	41	1.0000	41
0.80	12	15	0.75	60	0.02	0.00	12	48	0.8727	42
0.80	12	15	0.75	60	0.02	0.00	12	48	0.8727	42

APPENDIX G
U.S. FISH AND WILDLIFE SERVICE'S COORDINATION ACT REPORT SUMMARY

APPENDIX G
U. S. FISH AND WILDLIFE SERVICE'S COORDINATION ACT REPORT SUMMARY

U. S. Fish and Wildlife Service's (USFWS's) Coordination Act Report will contain a complete environmental impact analysis of the North Delta Program (NDP). The report will be incorporated into the EIR.

The impacts of the different features of the NDP, and the compensation needs arising from those impacts were evaluated using the USFWS's Habitat Evaluation Procedures (HEP). HEP is a methodology used to document the quality and quantity of available habitat for selected wildlife species.

HEP analyses were completed for features of the NDP, including alternatives for dredging and enlargement of selected north Delta channels.

USFWS is completing a report titled *Fish and Wildlife Resource Impacts and Compensation Needs, North Delta Program—A Detailed Assessment*, October 1990. This report, which documents the impacts and compensation needs analysis, using HEP, will be available for review at the Department of Water Resources. These are: *Enlargement of Clifton Court Forebay, Enlargement of Selected Channels in the Southern Delta*, and *A Canal Intertie–Clifton Court Forebay to Delta Mendota Canal*. All three documents are available for review at the Department of Water Resources. The final results of the analysis will be discussed in USFWS's draft Coordination Act Report.

A HEP application is based on the assumption that habitat for selected wildlife species or communities can be described by a model, which produces a Habitat Suitability Index (HSI). The HSI values are multiplied by the area of available habitat to obtain Habitat Units (HUs). HUs are used to 1) compare the relative value of different areas at the same point in time and 2) compare the relative value of the same area at future points in time. When the two types of comparisons are compared, the impacts of proposed or anticipated land and water use changes on wildlife habitat can be quantified.

The proposed NDP project design will incorporate wildlife mitigation and enhancement measures within the proposed channel enlargements and berm islands.

A summary of the analysis and results of the USFWS's NDP HEP follows.

Habitat Evaluation Procedures (HEP) Results

The U. S. Fish and Wildlife Service (USFWS) has completed a HEP analysis of the channel enlargements feature of the project. This analysis has focused on the projected impacts of the proposed channel enlargements to terrestrial wildlife. In addition, the Service's analysis was completed with limited participation of the other agencies involved with the project. Verification of the HEP results and completion of a final HEP report will necessitate continuing discussions with the HEP team consisting of appropriate representatives from DFG, DWR, USFWS and possibly USACE. Nevertheless, the HEP results are believed to fairly characterize, the overall positive benefits which would accrue to terrestrial wildlife with implementation of dredging and levee setbacks for various Delta channels.

The HEP analyses evaluated two general alternatives for channel enlargements using setback levee schemes. One alternative involved computer-generated profiles of channel dredging and enlargement for setback levees on project channels channels provided by Water Resources during April 1990. This alternative series of profiles, which involved relatively short setbacks along alternating sides of the channel, was divided prior to analysis into five distinct channel reaches (North Fork Mokelumne River, main stem Mokelumne River, Snodgrass Slough, South Fork Mokelumne River, and Little Potato/Connection Sloughs). The profiles did not specifically identify dimensions of waterside berms being constructed along either the setback levees or the existing levees which would become channel islands.

A series of 7.5-minute quad maps of the preferred alternative (5B) detailing proposed channel dredging and enlargement was provided by DWR in early October 1990. The preferred alternative (5B) shows seven alternating setback levee segments extending along the main stem and North Fork Mokelumne River from just downstream of Interstate Highway 5 to the San Joaquin River. Most of the existing levees (next to setback levees) would be left in place. Also, DWR proposed that 50–foot–wide waterside berms would be constructed along the old and new levees bordering the new channel area.

Table X summarizes the results of the HEP applications. For each enlargement option, one analysis was done assuming natural revegetation of levees and berms, and one analysis was completed assuming these areas would be intensively replanted. For the five channel segments involving the computer–generated profiles, all but one (Snodgrass Slough segment) would result in gains of habitat value (i.e., enhancement) under the natural revegetation scenario. Should barren areas be intensively replanted, considerable gains in habitat value would occur along all five channel segments.

The preferred alternative (5B) was evaluated as alternative 6 in Table X. Table X shows that for this alternative, the project would result in 10,454 Average Annual Habitat Units (AAHU's) being destroyed. However, with natural revegetation, 19,769 AAHU's would be provided for a net gain of 9,315 AAHU's. With intensive replanting, enhancement would increase to 16,403 AAHU's.

In addition to all overall increase in terrestrial wildlife habitat values, the preferred alternative for channel enlargements would have these benefits:

Blank page – discardAbout 87,000 feet (16.5 miles) of channel, which is now essentially barren of woody riparian vegetation, would be allowed to develop Palustrine Scrub–Shrub (PSS) and Palustrine Forest (PFO). An important new riparian corridor would be established.

Blank page – discardMuch of the affected reach would be allowed to develop dense woody riparian vegetation along both sides of the new channel islands created with the existing levee left in place and along the new setback levees. About 45 miles of heavily shaded improvement would be created along the 16.5 miles of levee improvement. Habitat values would thus be increased.

Blank page – discardSetback levees allow a maximum level of avoidance mitigation for Emergent Marsh (PEM), all relatively high–value cover types.

Blank page – discardWoody vegetation presently on maintained levees would increase substantially in habitat value with the cessation of maintenance activities.

Blank page – discardThree relatively large "oxbow" areas would be created between existing and setback levees. These oxbows could be developed into diverse, high–value biological resources habitats.

Blank page – discardAll negative impacts of channel enlargements would be fully mitigated onsite, with substantial enhancements remaining.

Blank page – discardImpacts to existing channel islands would be greatly reduced and possibly eliminated.

Blank page – discardLess than 6 acres of PFO cover would be destroyed while about 282 acres would be created.

Blank page – discardLess than three acres of PEM would be destroyed, while about 28 acres would be created.

Blank page – discardOnly about 0.5 acre of SRA Cover would be destroyed, while at least 11 acres would eventually be created.

Blank page – discardImpacts to valuable existing areas which would be avoided include the following: 6–7 miles and 40–50 Cover; 3–4 miles and 2–3 acres of SRA Cover; and 2–3 miles and about 2.5 acres of PEM Cover.

Blank page – discardAgricultural impacts would be confined largely to sometimes fallow and disturbed levee border "strips" on the islands, which in general are not as valuable to wildlife as interior island areas.

Blank page – discardThe additional miles of berm areas and channel islands produced by implementation of the preferred alternative (5B) should provide additional habitat for various rare, threatened, and endangered species of plants and animals.

Table X: Changes in habitat values as determined using HEP, which would occur with various channel enlargement alternatives involving the use of setback levees. For each alternative, the first set of figures given is without planting of new islands and berms, and the second set is with the intensive planting of these areas.

Channel Enlargement Alternatives	Average Annual Habitat Units (AAHU's)		
	Lost	Gained	Net Gained
1 North Fork Mokelumne River,	2812	4838	2026
Hypothetical Alternative*	2812	5719	2907
2 Mainstem Mokelumne River,	1846	2281	435
Hypothetical Alternative*	1846	2858	1012
3 Snodgrass Slough,	512	459	-53
Hypothetical Alternative*	539	691	152
4 South Fork Mokelumne River,	5835	5857	22
Hypothetical Alternative*	5570	8786	3216
5 Little Potato/Connection Sloughs	560	1245	685
Hypothetical Alternative*	654	1887	1233
6 North Fork/Mainstem Mokelumne River,	10454	19769	9315
Preferred Alternative**	10454	26857	16403

* Setback alternating between sides of existing channel, with computer-generated levee and channel profiles.

** Seven alternating setback segments, as provided by DWR on USGS quadrangle maps 10/04/90. This is DWR's preferred alternative. Detailed levee and channel profiles were not provided.

APPENDIX H
CONSTRUCTION REPORT SUMMARY

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The principal features of the North Delta Water Management Program include improvements of the channels either by dredging of the channels or enlargement by dredging of existing channels and excavating new parallel channels with setback levees. Alternatives 2A, 2B, 3A and 3B would involve only dredging of channels and alternatives 4A, 4B, 5A and 5B would include enlargement of channels with setback levees.

Channel Dredging–The channels would be increased in cross–sectional areas to the extent possible by dredging the channel bottoms to an elevation of about 20 feet below mean sea level while maintaining a side slope no steeper than 2:1 on either side of the existing channel. Dredging can be accomplished by the use of barge–mounted clamshell or dragline. Hydraulic suction dredge may have to be employed in segments where the channels are narrow in width. The materials to be excavated from the channel bottom will be placed on the land side of the existing levee. The excess dredged materials may also be used for water side berm construction.

Channel Enlargement With Setback Levee–This includes excavation of a new channel with a new setback levee in addition to dredging of the existing channel. The maximum depth of excavation will be about 20 feet below mean sea level for both the existing and the new channels with water side slopes no steeper than 2:1. The exterior side slopes of the setback levee will vary from 3:1 to 5:1 depending on the depth of underlying peat in the foundation. A flatter slope on the exterior side is provided in areas where deep layers of peat exist. In addition to the new setback levee, a berm of about 50 feet in width would be provided on each side of the new channel to support riparian vegetation and enhance wildlife habitat.

The relocation of structures, the possible modification of highways and bridges, and the use of county roads for hauling would cause some delays and inconveniences to local residents due to detours and rerouting of traffic in the affected areas. However, the contractor will be instructed to avoid peak traffic hours and weekends as much as possible and to have adequate signs and personnel to move traffic safely and expeditiously through construction zones.

Local water quality problems, such as increased turbidity, can be expected for a short time in some channels due to construction of bridge piers, cofferdams, and dredging. This impact will be extended through the construction period only, and will end once the project is operational. All necessary permits will be obtained before construction begins.

Increased noise due to construction traffic and pile driving equipment at some sites would be unavoidable, but this effect would be localized and will have minor impacts on the public. The project area is not immediately adjacent to any metropolitan areas. These activities may have some effect on local wildlife. The contractor will have to meet the requirements of the California Occupational Safety and Health Administration (CALOSHA), which should preclude unacceptable noise level.

Since the project is in a rural area, dust would not become a serious problem during excavation and hauling. The contractor will be required to minimize the dust by watering or other means of control. The dust that cannot be controlled is not expected to exceed that caused by normal farming activities. The contract specifications may also require the contractor to apply appropriate dust control measures on detours and operating roads.

Where land acquisition is part of a project component, DWR and other involved agencies will assist each person, family, business, farm, or non–profit organization to relocate or find an equivalent property. Every effort will be made to keep inconvenience to a minimum and to allow sufficient time for relocation. If necessary, a local office will be established for better service.

Impacts on fish migration from construction will be minimal. Cofferdams, built to divert water from bridge construction sites, will extend slightly into the river and may cause temporary increases in turbidity. The changed flow pattern from the cofferdams may temporarily impact fish migration, depending on timing and construction methods used.

Utilities, if any, such as gas and water supply lines, power and telephone cables, underground cables, and wells that would be disrupted by the project would be replaced or relocated at project expense. To minimize disruption of service, the relocation of such facilities would be handled by the utility company involved. Utility cables or pipelines in the project area will be either overhead or underground, as appropriate. Utility companies will be notified of construction in advance.

Wells within the right-of-way boundary would be either plugged and abandoned, replaced or otherwise compensated for. The following tables and figures summarize preliminary alternative estimates of quantities and costs. Detailed supporting documentation is available for inspection in the Department files.

Table H-1 Summary of Estimated Costs for Different Project Alternatives

Project Alternatives		Cost in Dollars*
1.	No Action --	---
2A.	Dredge the South Fork Mokelumne River	29,000.000
2B.	Dredge the South Fork Mokelumne River and Enlarge the Delta Cross Channel Gates	59,000,000
3A.	Dredge the South Fork and North Fork Mokelumne River	53,000,000
3B.	Dredge the South Fork and North Fork Mokelumne River and Enlarge the Delta Cross Channel Gates	83,000,000
4A.	Enlarge the South Fork Mokelumne River and Dredge the North Fork Mokelumne River	368,000,000
4B.	Enlarge the South Fork Mokelumne River and Dredge the North Fork Mokelumne River and Enlarge the Delta Cross Channel Gates	398,000,000
5A.	Dredge the South Fork Mokelumne River and Enlarge the North Fork Mokelumne River	260,000,000
5B.	Dredge the South Fork Mokelumne River and Enlarge the North Fork Mokelumne River and Enlarge the Delta Cross Channel Gates	290,000,000**
6A.	Create an Island Floodway	250,000,000
6B.	Create an island floodway and Enlarge the Delta Cross Channel	280,000,000

*Not including O & M and mitigation costs

**Preferred Alternative

Table H-2 Summary of Estimated Major Material Quantities Needed for Construction of North Delta Program Facilities

Item	Unit	Project Alternatives									
		2A	2B	3A	3B	4A	4B	5A	5B	6A	6B
Excavate Existing Channel	CY	3,527,000	3,527,000	6,548,000	6,548,000	15,569,000	15,569,000	10,831,000	10,831,000	2,937,000	2,937,000
Reinforce Existing Levee	CY	219,000	219,000	295,000	295,000	1,280,000	1,280,000	806,000	806,000	---	---
Excavate New Channel	CY	---	786,000	---	786,000	9,950,000	10,736,000	7,960,000	8,746,000	---	786,000
Berm Embankment using Channel Excavation	CY	---	---	---	---	2,980,000	2,980,000	1,811,000	1,811,000	---	---
Levee Embankment using Channel Excavation	CY	---	123,000	---	123,000	2,808,000	2,931,000	1,388,000	1,511,000	---	123,000
Levee Embankment using Imported Borrow	CY	---	17,000	---	17,000	9,762,000	9,779,000	5,507,000	5,524,000	2,592,000	2,609,000
Riprap	TON	126,000	189,000	243,000	306,000	1,654,000	1,717,000	1,423,000	1,486,000	1,944,000	2,007,000
Bedding (6" under riprap)	TON	36,000	50,000	70,000	84,000	550,000	564,000	463,000	477,000	550,000	564,000
Geotextile	SF	1,117,000	1,533,000	2,156,000	2,572,000	31,855,000	32,271,000	27,861,000	28,277,000	13,496,000	13,912,000
Concrete-Structural	CY	---	16,000	---	16,000	10,000	26,000	10,000	26,000	39,300	55,300
Reinforcing Steel	LB	---	3,288,000	---	3,288,000	2,392,000	5,680,000	2,392,000	5,680,000	8,549,000	11,837,000
Structural Steel	LB	---	720,000	---	720,000	---	720,000	---	720,000	---	720,000
Structural Excavation	CY	---	123,000	---	123,000	---	123,000	---	123,000	17,000	140,000
Land Acquisition	AC	---	15	---	15	1,229	1,244	1,041	1,056	12,700	12,715
Alternative Costs (in $1,000) (NOT INCLUDING MITIGATION COSTS)		$29,000	$59,000	$53,000	$83,000	$368,000	$398,000	$260,000	$290,000	$250,000	$280,000

[shaded] Preferred Alternative

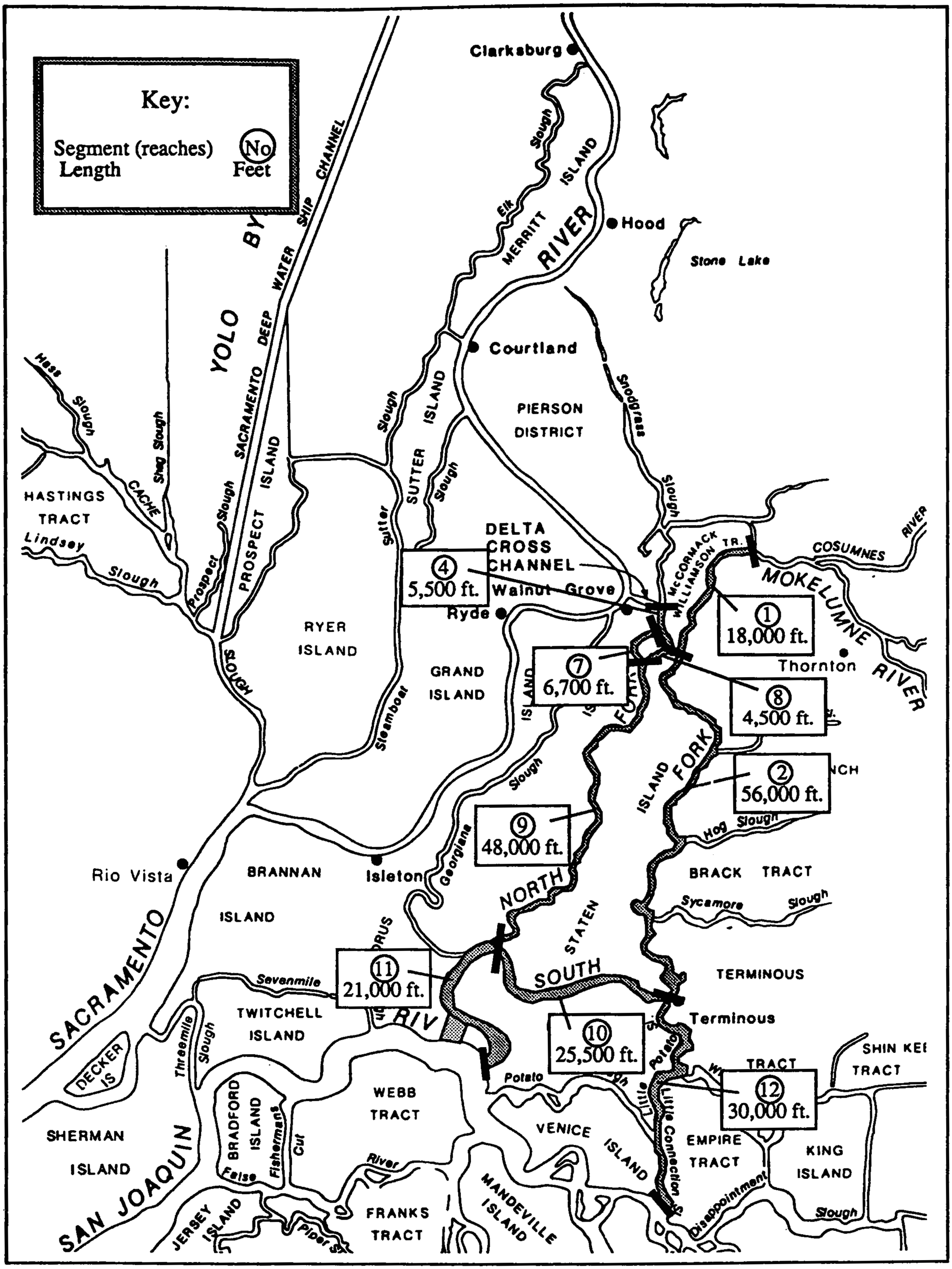


Figure H-1. Segments (reaches) and lengths of channels to be improved

Alternative 2A and 2B

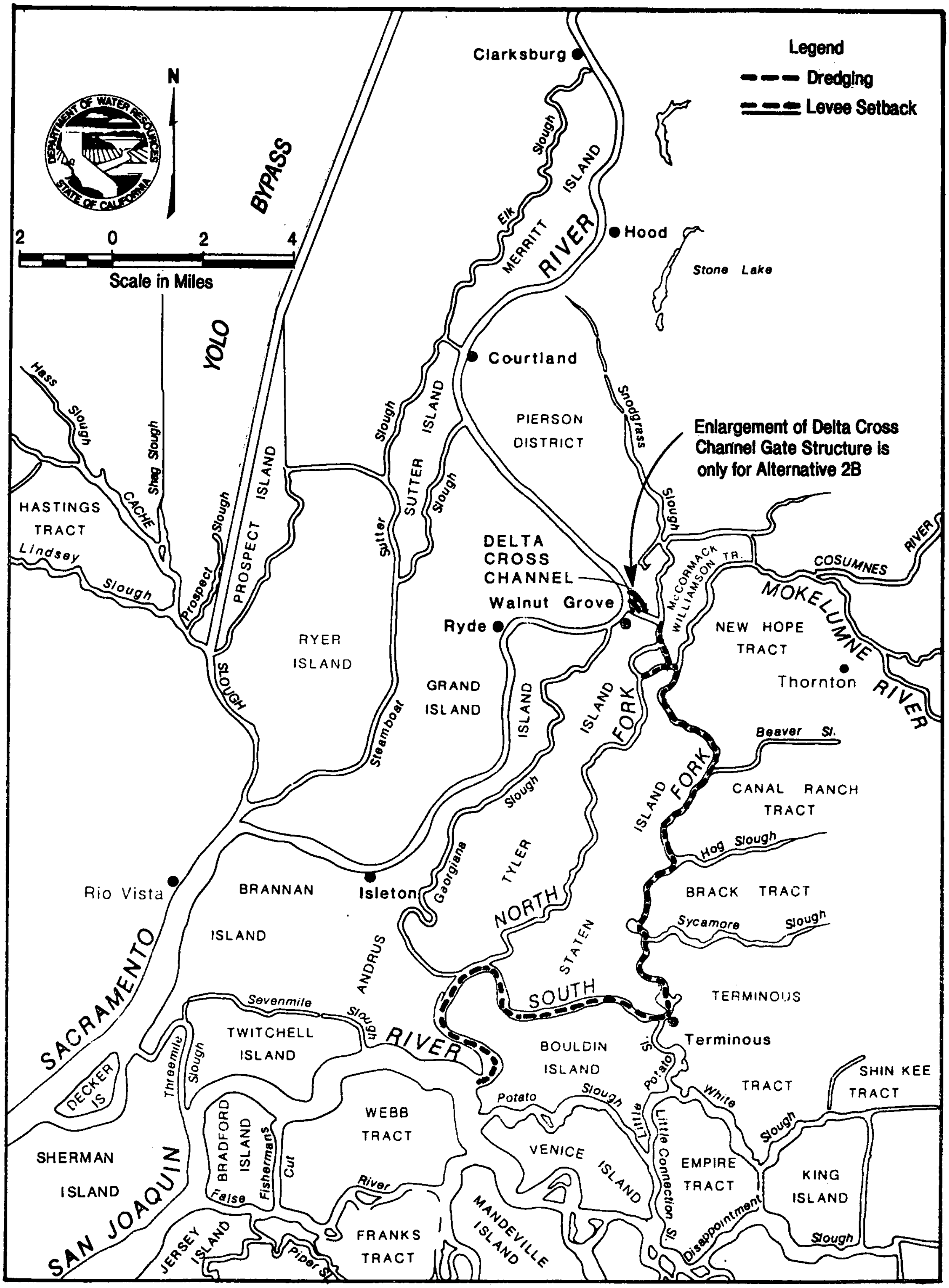


FIG. H-2

Table H-3

Alternative 2A

Dredge the South Fork Mokelumne River

Item	unit	Reach 1	Reach 2	Reach 4a	Reach 4b	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	Quantity	Unit Cost	Item Cost
Excavate Existing Channel	CY		2,761,000	294,962	470,962						3,526,924	$4.00	$14,108,000
Reinforce Existing Levee	CY		154,200	14,814	14,814		35,592				219,420	$3.00	$658,000
Excavate New Channel	CY											$2.80	$0
Berm Embankment using Channel Excavation	CY											$3.00	$0
Levee Embankment using Channel Excavation	CY											$1.00	$0
Levee Embankment using imported borrow	CY											$7.00	$0
Geotextile (under embnk.)	SF											$0.25	$0
Riprap	Ton		101,365	5,076	10,152		9,076				125,669	$15.00	$1,885,000
Bedding (6" thick)	Ton		29,283	1,472	2,933		2,622				36310	$14.00	$508,000
Geotextile under bedding	SF		901,019	45,120	90,240		80,675				1,117,054	$0.25	$279,000
Aggregate Base	Ton											$25.00	$0
Clearing and Grubbing	AC		91		12		20				123	$700.00	$86,000
Enlarge Delta Cross Channel Gate Structure	LS												
Subtotal-1													$17,524,000
Miscellaneous 20%													$3,505,000
Subtotal-2													$21,029,000
Land Acquisition	AC											$2,000.00	$0
Utilities	LS		$215,000		$15,000		$38,000						$268,000
Bridges	LS												$0
Subtotal-3													$21,297,000
S.O. plus Contingencies 35%													$7,454,000
Total Cost													$28,751,000

Table H-4
Alternative 2B
Dredge the South Fork Mokelumne River and Enlarge the Delta Channel Gate Structure

Item	unit	Reach 1	Reach 2	Reach 4a	Reach 4b	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	Quantity	Unit Cost	Item Cost
Excavate Existing Channel	CY		2,761,000	294,962	470,962						3,526,924	$4.00	$14,108,000
Reinforce Existing Levee	CY		154,200	14,814	14,814		35,592				219,420	$3.00	$658,000
Excavate New Channel	CY											$2.80	$0
Berm Embankment using Channel Excavation	CY											$3.00	$0
Levee Embankment using Channel Excavation	CY											$1.00	$0
Levee Embankment using imported borrow	CY											$7.00	$0
Geotextile (under embnk.)	SF											$0.25	$0
Riprap	Ton		101,365	5,076	10,152		9,076				125,669	$15.00	$1,885,000
Bedding (6" thick)	Ton		29,283	1,472	2,933		2,622				36310	$14.00	$508,000
Geotextile under bedding	SF		901,019	45,120	90,240		80,675				1,117,054	$0.25	$279,000
Aggregate Base	Ton											$25.00	$0
Clearing and Grubbing	AC		91		12		20				123	$700.00	$86,000
Enlarge Delta Cross Channel Gate Structure	LS												$18,612,000
Subtotal-1													$36,136,000
Miscellaneous 20%													$7,227,000
Subtotal-2													$43,363,000
Land Acquisition	AC											$2,000.00	$0
Utilities	LS		$215,000		$15,000		$38,000						$268,000
Bridges	LS												$0
Subtotal-3													$43,631,000
S.O. plus Contingencies 35%													$15,271,000
Total Cost													$58,902,000

Alternative 3A and 3B

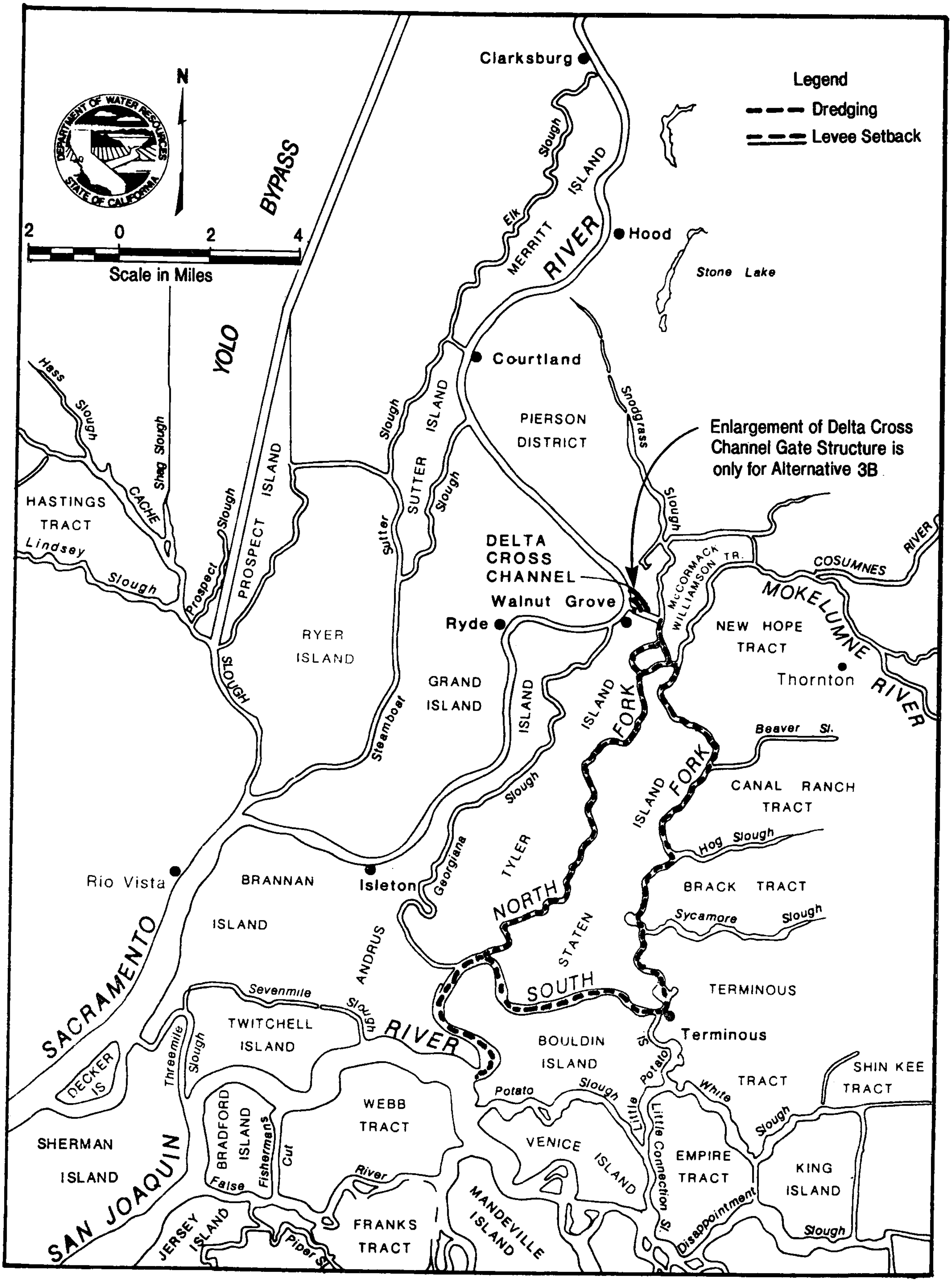


FIG. H-3

Table H-5

Alternative 3A

Dredge the South Fork and North Fork Mokelumne River

Item	unit	Reach 1	Reach 2	Reach 4a	Reach 4b	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	Quantity	Unit Cost	Item Cost
Excavate Existing Channel	CY		2,761,000	294,962	470,962	754,517	0	2,266,557			6,547,998	$4.00	$26,192,000
Reinforce Existing Levee	CY		154,200	14,814	14,814	25,925	35,592	50,000			295,345	$3.00	$886,000
Excavate New Channel	CY											$2.80	$0
Berm Embankment using Channel Excavation	CY											$3.00	$0
Levee Embankment using Channel Excavation	CY											$1.00	$0
Levee Embankment using imported borrow	CY											$7.00	$0
Geotextile (under embnk.)	SF											$0.25	$0
Riprap	Ton		101,365	5,076	10,152	18,637	9,076	98,214			242,520	$15.00	$3,638,000
Bedding (6" thick)	Ton		29,283	1,472	2,933	5,404	2,622	28,373			70087	$14.00	$981,000
Geotextile under bedding	SF		901,019	45,120	90,240	165,773	80,675	873,017			2,155,844	$0.25	$539,000
Aggregate Base	Ton											$25.00	$0
Clearing and Grubbing	AC		91		12	18	20	106			247	$700.00	$173,000
Enlarge Delta Cross Channel Gate Structure	LS												
Subtotal-1													$32,409,000
Miscellaneous 20%													$6,482,000
Subtotal-2													$38,891,000
Land Acquisition	AC											$2,000.00	$0
Utilities	LS		$215,000		$15,000		$38,000	$113,000					$381,000
Bridges	LS												$0
Subtotal-3													$39,272,000
S.O. plus Contingencies 35%													$13,745,000
Total Cost													$53,017,000

Table H-6

Alternative 3B

Dredge the South Fork and North Fork Mokelumne River and Enlarge the Delta Cross Channel Gate Structure

Item	unit	Reach 1	Reach 2	Reach 4a	Reach 4b	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	Quantity	Unit Cost	Item Cost
Excavate Existing Channel	CY		2,761,000	294,962	470,962	754,517	0	2,266,557			6,547,998	$4.00	$26,192,000
Reinforce Existing Levee	CY		154,200	14,814	14,814	25,925	35,592	50,000			295,345	$3.00	$886,000
Excavate New Channel	CY											$2.80	$0
Berm Embankment using Channel Excavation	CY											$3.00	$0
Levee Embankment using Channel Excavation	CY											$1.00	$0
Levee Embankment using imported borrow	CY											$7.00	$0
Geotextile (under embnk.)	SF											$0.25	$0
Riprap	Ton		101,365	5,076	10,152	18,637	9,076	98,214			242,520	$15.00	$3,638,000
Bedding (6" thick)	Ton		29,283	1,472	2,933	5,404	2,622	28,373			70087	$14.00	$981,000
Geotextile under bedding	SF		901,019	45,120	90,240	165,773	80,675	873,017			2,155,844	$0.25	$539,000
Aggregate Base	Ton											$25.00	$0
Clearing and Grubbing	AC		91		12	18	20	106			247	$700.00	$173,000
Enlarge Delta Cross Channel Gate Structure	LS												$18,612,000
Subtotal-1													$51,021,000
Miscellaneous 20%													$10,204,000
Subtotal-2													$61,225,000
Land Acquisition	AC											$2,000.00	$0
Utilities	LS		$215,000		$15,000		$38,000	$113,000					$381,000
Bridges	LS												$0
Subtotal-3													$61,606,000
S.O. plus Contingencies 35%													$21,562,000
Total Cost													$83,168,000

Alternative 4A and 4B

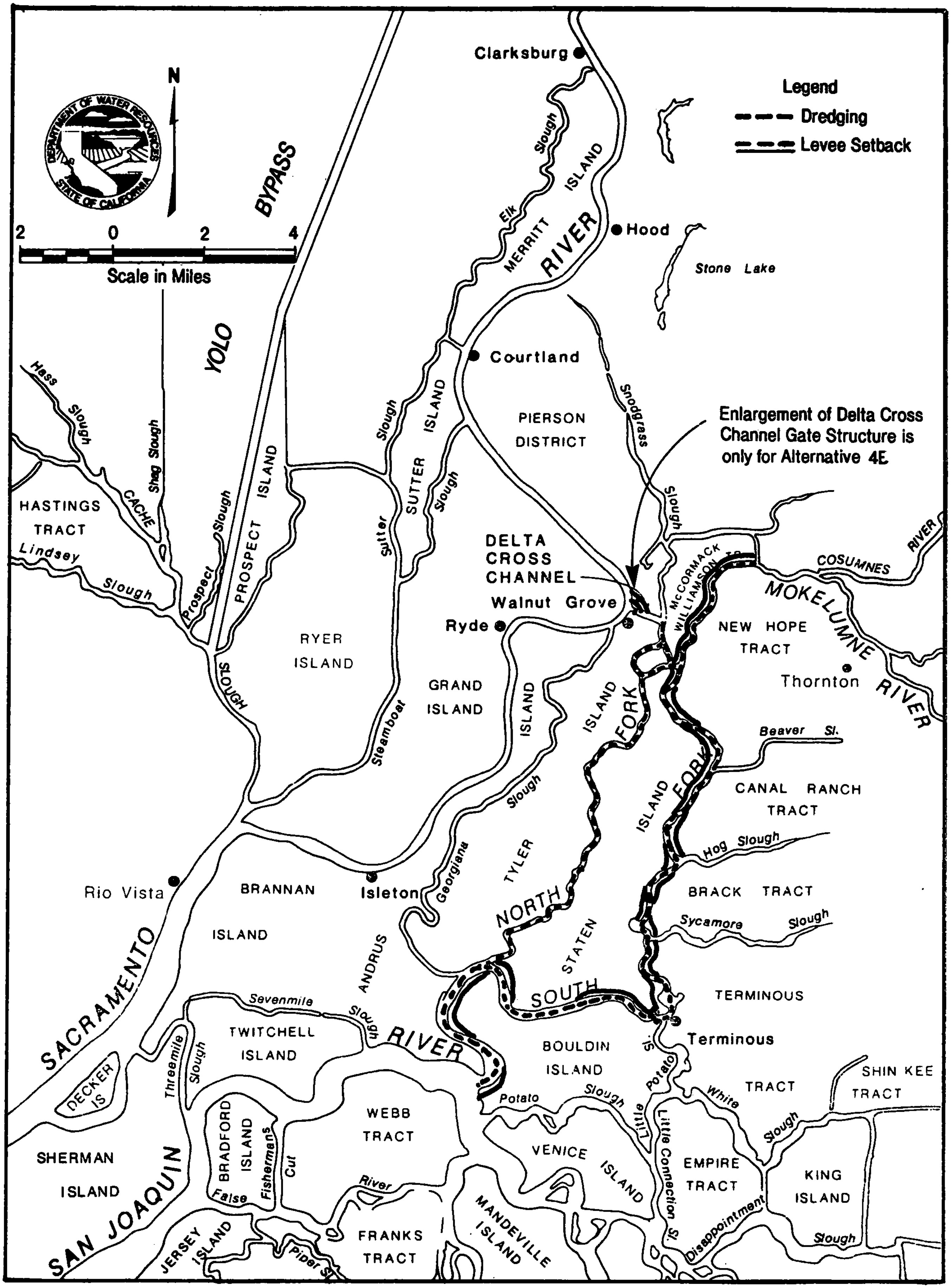


FIG. H-4

Table H-7

Alternative 4A

Enlarge the South Fork and Dredge the North Fork of the Mokelumne River

Item	unit	Reach 1	Reach 2	Reach 4a	Reach 4b	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	Quantity	Unit Cost	Item Cost
Excavate Existing Channel	CY	333,600	2,761,000	294,962	470,962	754,517	0	2,266,557	4,671,294	2,287,400	13,840,292	$4.00	$55,361,000
Reinforce Existing Levee	CY	115,703	154,200	14,814	14,814	25,925	35,592	50,000	467,000	457,500	1,335,548	$3.00	$4,007,000
Excavate New Channel	CY	4,403,111	3,113,494		448,296		1,111,111		398,600	306,000	9,780,612	$2.80	$27,386,000
Berm Embankment using Channel Excavation	CY		398,461		29,629		18,518		1,583,000	950,000	2,979,608	$3.00	$8,939,000
Levee Embankment using Channel Excavation	CY	641,866							1,420,000	851,750	2,913,616	$1.00	$2,914,000
Levee Embankment using imported borrow	CY		7,330,300		139,777		125,722		1,420,000	851,750	9,867,549	$7.00	$69,073,000
Geotextile (under embnk.)	SF		8,327,000				474,000		3,451,000	2,050,250	14,302,250	$0.25	$3,576,000
Riprap	TON	272,232	870,823	25,380	50,760	18,637	45,380	98,214	166,725	110,175	1,658,326	$15.00	$24,875,000
Bedding (6" thick)	TON	107,653	264,015	7,360	14,664	5,404	13,109	28,373	66,690	44,070	551,338	$14.00	$7,719,000
Geotextile under bedding	SF	3,329,718	8,425,093	225,600	451,200	165,773	403,377	873,017	2,223,000	1,469,000	17,565,778	$0.25	$4,391,000
Aggregate Base	TON	12,320	21,112		2,240		2,240		9,000	5,400	52,312	$25.00	$1,308,000
Clearing and Grubbing	LS	343	453		59	18	99	106	79	49	1,206	$700.00	$844,000
Subtotal-1													$210,393,000
Miscellaneous 20%													$42,079,000
Subtotal-2													$252,472,000
Land Acquisition	AC	182	347						210	145	884	$2,000.00	$1,768,000
Utilities	LS	$85,000	$1,075,000		$72,000		$190,000	$113,000	$100,000				$1,635,000
Bridges	LS		$7,924,000				$500,000						$8,424,000
Subtotal-3													$264,299,000
S.O. plus Contingencies 35%													$92,505,000
Total Cost													$356,804,000

Table H-8

Alternative 4B

Enlarge the South Fork and Dredge the North Fork of the Mokelumne River

Item	unit	Reach 1	Reach 2	Reach 4a	Reach 4b	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	Quantity	Unit Cost	Item Cost
Excavate Existing Channel	CY	333,600	2,761,000	294,962	470,962	754,517	0	2,266,557	4,671,294	2,287,400	13,840,292	$4.00	$55,361,000
Reinforce Existing Levee	CY	115,703	154,200	14,814	14,814	25,925	35,592	50,000	467,000	457,500	1,335,548	$3.00	$4,007,000
Excavate New Channel	CY	4,403,111	3,113,494		448,296		1,111,111		398,600	306,000	9,780,612	$2.80	$27,386,000
Berm Embankment using Channel Excavation	CY		398,461		29,629		18,518		1,583,000	950,000	2,979,608	$3.00	$8,939,000
Levee Embankment using Channel Excavation	CY	641,866							1,420,000	851,750	2,913,616	$1.00	$2,914,000
Levee Embankment using imported borrow	CY		7,330,300		139,777		125,722		1,420,000	851,750	9,867,549	$7.00	$69,073,000
Geotextile (under embnk.)	SF		8,327,000				474,000		3,451,000	2,050,250	14,302,250	$0.25	$3,576,000
Riprap	TON	272,232	870,873	25,380	50,760	18,637	45,380	98,214	166,725	110,175	1,658,376	$15.00	$24,876,000
Bedding (6" thick)	TON	107,653	264,015	7,360	14,664	5,404	13,109	28,373	66,690	44,070	551,338	$14.00	$7,719,000
Geotextile under bedding	SF	3,329,718	8,425,093	225,600	451,200	165,773	403,377	873,017	2,223,000	1,469,000	17,565,778	$0.25	$4,391,000
Aggregate Base	TON	12,320	21,112		2,240		2,240		9,000	5,400	52,312	$25.00	$1,308,000
Clearing and Grubbing	LS	343	453		59	18	99	106	79	49	1,206	$700.00	$844,000
Enlarge Delta Cross Channel Gate Structure													$18,612,000.00
Subtotal-1													$229,006,000
Miscellaneous 20%													$45,801,000
Subtotal-2													$274,807,000
Land Acquisition	AC	182	347						210	145	884	$2,000.00	$1,768,000
Utilities	LS	$85,000	$1,075,000		$72,000		$190,000	$113,000	$100,000				$1,635,000
Bridges	LS		$7,924,000				$500,000						$8,424,000
Subtotal-3													$286,634,000
S.O. plus Contingencies 35%													$100,322,000
Total Cost													$386,956,000

Alternative 4AA and 4BB

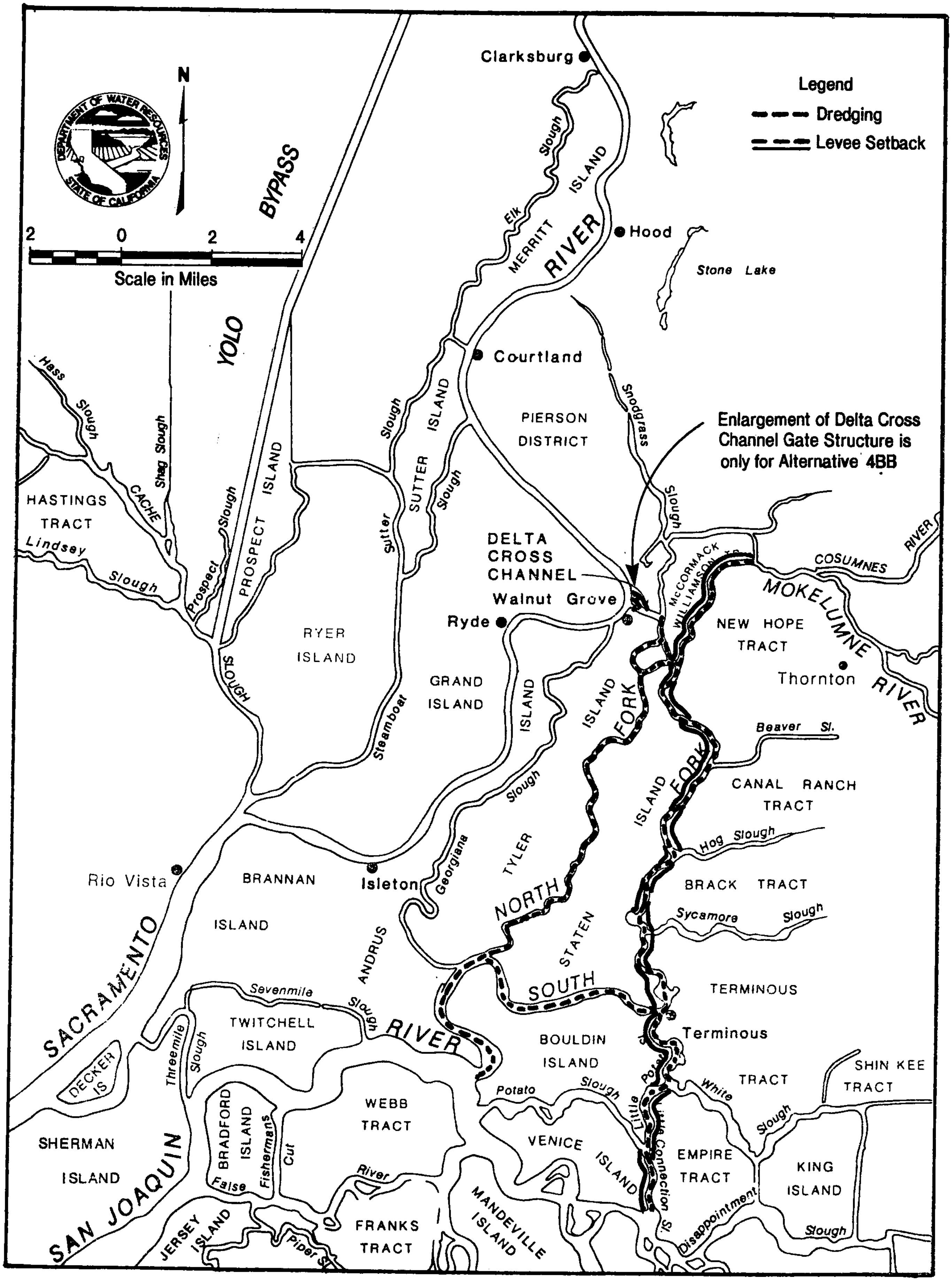


FIG. H-5

Table H-9

Alternative 4AA

Enlarge the South Fork and Dredge the North Fork of the Mokelumne River, and enlarge Little Poteto Slough

Item	unit	Reach 1	Reach 2	Reach 4a	Reach 4b	Reach 7	Reach 8	Reach 9	Reach 12	Reach 11	Quantity	Unit Cost	Item Cost
Excavate Existing Channel	CY	333,600	2,761,000	294,962	470,962	754,517	0	2,266,557	2,765,600		9,647,198	$4.00	$38,589,000
Reinforce Existing Levee	CY	115,703	154,200	14,814	14,814	25,925	35,592	50,000	277,000		688,048	$3.00	$2,064,000
Excavate New Channel	CY	4,403,111	3,113,494		448,296		1,111,111		1,553,300		10,629,312	$2.80	$29,762,000
Berm Embankment using Channel Excavation	CY		398,461		29,629		18,518		3,167,000		3,613,608	$3.00	$10,841,000
Levee Embankment using Channel Excavation	CY	641,866							2,487,000		3,128,866	$1.00	$3,129,000
Levee Embankment using imported borrow	CY		7,330,300		139,777		125,722		2,487,000		10,082,799	$7.00	$70,580,000
Geotextile (under embnk.)	SF		8,327,000				474,000		6,765,000		15,566,000	$0.25	$3,892,000
Riprap	TON	272,232	870,873	25,380	50,760	18,637	45,380	98,214	272,000		1,653,476	$15.00	$24,802,000
Bedding (6" thick)	TON	107,653	264,015	7,360	14,664	5,404	13,109	28,373	109,000		549,578	$14.00	$7,694,000
Geotextile under bedding	SF	3,329,718	8,425,093	225,600	451,200	165,773	403,377	873,017	3,627,000		17,500,778	$0.25	$4,375,000
Aggregate Base	TON	12,320	21,112		2,240		2,240		18,000		55,912	$25.00	$1,398,000
Clearing and Grubbing	LS	343	453		59	18	99	106	148		1,226	$700.00	$858,000
Subtotal-1													$197,984,000
Miscellaneous 20%													$39,597,000
Subtotal-2													$237,581,000
Land Acquisition	AC	182	347						582		1,111	$2,000.00	$2,222,000
Utilities	LS	$85,000	$1,075,000		$72,000		$190,000	$113,000	$100,000				$1,635,000
Bridges	LS		$7,924,000				$500,000						$8,424,000
Subtotal-3													$249,862,000
S.O. plus Contingencies 35%													$87,452,000
Total Cost													$337,314,000

Table H-10

Alternative 4BB

Enlarge the South Fork and Dredge the North Fork of the Mokelumne River and enlarge Little Poteto Slough

Item	unit	Reach 1	Reach 2	Reach 4a	Reach 4b	Reach 7	Reach 8	Reach 9	Reach 12	Reach 11	Quantity	Unit Cost	Item Cost
Excavate Existing Channel	CY	333,600	2,761,000	294,962	470,962	754,517	0	2,266,557	2,765,600		9,647,198	$4.00	$38,589,000
Reinforce Existing Levee	CY	115,703	154,200	14,814	14,814	25,925	35,592	50,000	277,000		688,048	$3.00	$2,064,000
Excavate New Channel	CY	4,403,111	3,113,494		448,296		1,111,111		1,553,300		10,629,312	$2.80	$29,762,000
Berm Embankment using Channel Excavation	CY		398,461		29,629		18,518		3,167,000		3,613,608	$3.00	$10,841,000
Levee Embankment using Channel Excavation	CY	641,866							2,487,000		3,128,866	$1.00	$3,129,000
Levee Embankment using imported borrow	CY		7,330,300		139,777		125,722		2,487,000		10,082,799	$7.00	$70,580,000
Geotextile (under embnk.)	SF		8,327,000				474,000		6,765,000		15,566,000	$0.25	$3,892,000
Riprap	TON	272,232	870,873	25,380	50,760	18,637	45,380	98,214	272,000		1,653,476	$15.00	$24,802,000
Bedding (6" thick)	TON	107,653	264,015	7,360	14,664	5,404	13,109	28,373	109,000		549,578	$14.00	$7,694,000
Geotextile under bedding	SF	3,329,718	8,425,093	225,600	451,200	165,773	403,377	873,017	3,627,000		17,500,778	$0.25	$4,375,000
Aggregate Base	TON	12,320	21,112		2,240		2,240		18,000		55,912	$25.00	$1,398,000
Clearing and Grubbing	LS	343	453		59	18	99	106	148		1,226	$700.00	$858,000
Enlarge Delta Cross Channel Gate Structure													$18,612,000.00
Subtotal-1													$216,596,000
Miscellaneous 20%													$43,319,000
Subtotal-2													$259,915,000
Land Acquisition	AC	182	347						582		1,111	$2,000.00	$2,222,000
Utilities	LS	$85,000	$1,075,000		$72,000		$190,000	$113,000	$100,000				$1,635,000
Bridges	LS		$7,924,000				$500,000						$8,424,000
Subtotal-3													$272,196,000
S.O. plus Contingencies 35%													$95,269,000
Total Cost													$367,465,000

Alternative 5A and 5B (Preferred Alternative)

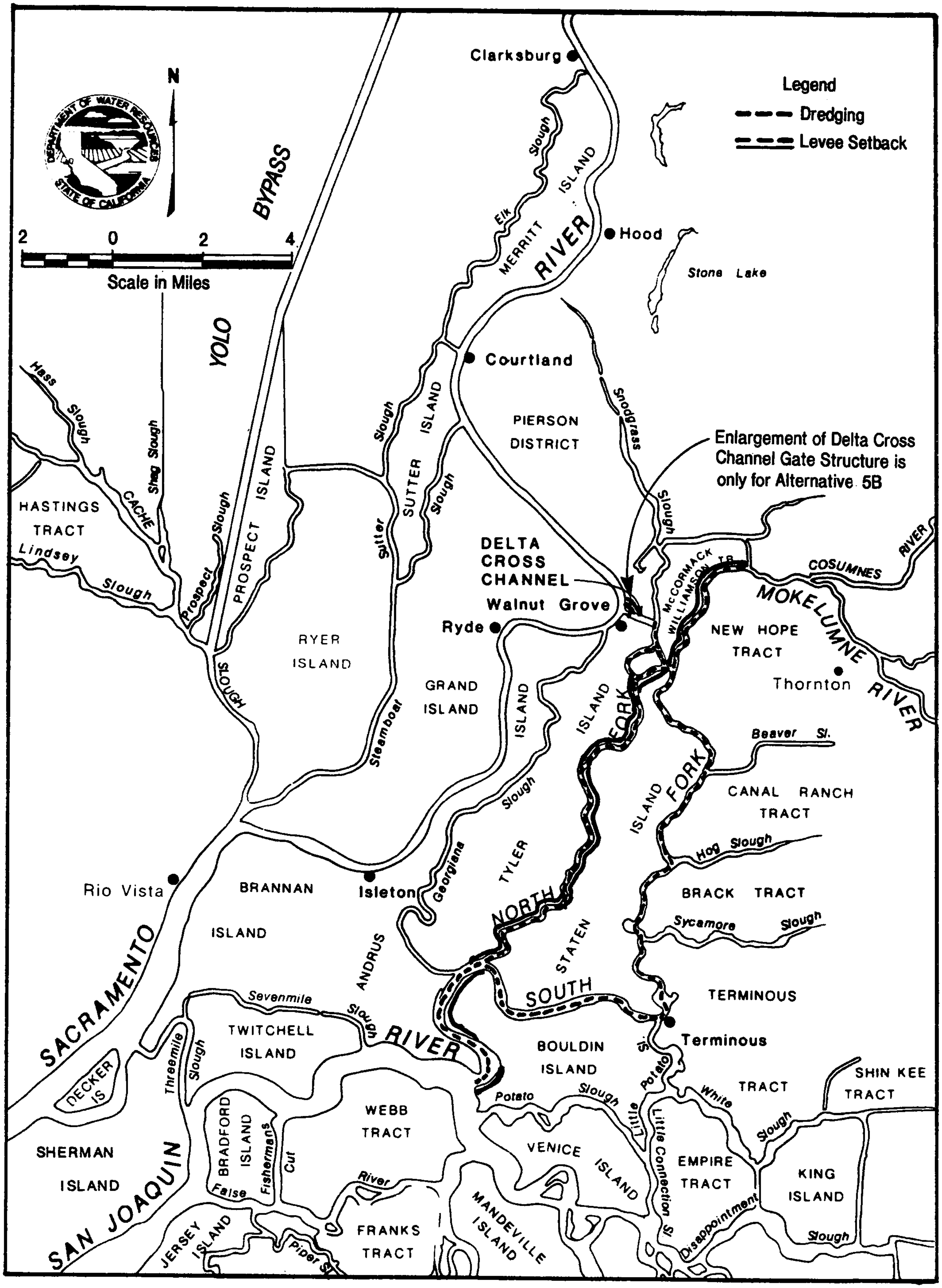


FIG. H-6

Table H-11

Alternative 5A

Enlarge the North Fork and Dredge the South Fork and Enlarge the Delta Cross Channel Gate Structure

Item	unit	Reach 1	Reach 2	Reach 4a	Reach 4b	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	Quantity	Unit Cost	Item Cost
Excavate Existing Channel	CY	333,600	2,761,000	294,962	470,962	754,517	0	2,266,557		3,949,563	10,831,161	$4.00	$43,325,000
Reinforce Existing Levee	CY	115,703	154,200	14,814	14,814	25,925	35,592	50,000		395,000	806,048	$3.00	$2,418,000
Excavate New Channel	CY	4,403,111			448,296		1,111,111	1,811,462		186,000	7,959,980	$2.80	$22,288,000
Berm Embankment using Channel Excavation	CY				29,629		18,518	812,456		950,000	1,810,603	$3.00	$5,432,000
Levee Embankment using Channel Excavation	CY	641,866								746,400	1,388,266	$1.00	$1,388,000
Levee Embankment using imported borrow	CY				139,777		125,722	4,494,826		746,400	5,506,725	$7.00	$38,547,000
Geotextile (under embnk.)	SF		1,665,400				474,000	9,013,600		2,091,000	13,244,000	$0.25	$3,311,000
Riprap	Ton	272,232	101,365	25,380	50,760	18,637	45,380	803,072		106,200	1,423,026	$15.00	$21,345,000
Bedding (6" thick)	Ton	107,653	29,283	7,360	14,684	5,404	13,109	242,665		42,470	462,608	$14.00	$6,477,000
Geotextile under bedding	SF	3,329,718	901,019	225,600	451,200	165,773	403,377	7,725,086		1,415,700	14,617,473	$0.25	$3,654,000
Aggregate Base	Ton	12,320			2,240		2,240	70,280		5,400	92,480	$25.00	$2,312,000
Clearing and Grubbing	LS	150	91		59	18	99	483		48	948	$700.00	$664,000
Subtotal-1													$151,161,000
Miscellaneous 20%													$30,232,000
Subtotal-2													$181,393,000
Land Acquisition	AC	210						690		120	1,020	$2,000.00	$2,040,000
Utilities	LS	$85,000	$215,000		$72,000		$190,000	$113,000					$675,000
Bridges	LS						$500,000	$7,924,000					$8,424,000
Subtotal-3													$192,532,000
S.O. plus Contingencies 35%													$67,386,000
Total Cost													$259,918,000

Table H-12

Alternative 5B (Preferred Alternmative)

Enlarge the North Fork and Dredge the South Fork and Enlarge the Delta Cross Channel Gate Structure

Item	unit	Reach 1	Reach 2	Reach 4a	Reach 4b	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	Quantity	Unit Cost	Item Cost
Excavate Existing Channel	CY	333,600	2,761,000	294,962	470,962	754,517	0	2,266,557		3,949,563	10,831,161	$4.00	$43,325,000
Reinforce Existing Levee	CY	115,703	154,200	14,814	14,814	25,925	35,592	50,000		395,000	806,048	$3.00	$2,418,000
Excavate New Channel	CY	4,403,111			448,296		1,111,111	1,811,462		186,000	7,959,980	$2.80	$22,288,000
Berm Embankment using Channel Excavation	CY				29,629		18,518	812,456		950,000	1,810,603	$3.00	$5,432,000
Levee Embankment using Channel Excavation	CY	641,866								746,400	1,388,266	$1.00	$1,388,000
Levee Embankment using imported borrow	CY				139,777		125,722	4,494,826		746,400	5,506,725	$7.00	$38,547,000
Geotextile (under embnk.)	SF		1,665,400				474,000	9,013,600		2,091,000	13,244,000	$0.25	$3,311,000
Riprap	Ton	272,232	101,365	25,380	50,760	18,637	45,380	803,072		106,200	1,423,026	$15.00	$21,345,000
Bedding (6" thick)	Ton	107,653	29,283	7,360	14,664	5,404	13,109	242,665		42,470	462,608	$14.00	$6,477,000
Geotextile under bedding	SF	3,329,718	901,019	225,600	451,200	165,773	403,377	7,725,086		1,415,700	14,617,473	$0.25	$3,654,000
Aggregate Base	Ton	12,320			2,240		2,240	70,280		5,400	92,480	$25.00	$2,312,000
Clearing and Grubbing	LS	150	91		59	18	99	483		48	948	$700.00	$664,000
Enlarge Delta Cross Channel Gate Structure	LS												$18,612,000
Subtotal-1													$169,773,000
Miscellaneous 20%													$33,955,000
Subtotal-2													$203,728,000
Land Acquisition	AC	210						690		120	1,020	$2,000.00	$2,040,000
Utilities	LS	$85,000	$215,000		$72,000		$190,000	$113,000					$675,000
Bridges	LS						$500,000	$7,924,000					$8,424,000
Subtotal-3													$214,867,000
S.O. plus Contingencies 35%													$75,203,000
Total Cost													$290,070,000

Alternative 5AA and 5BB

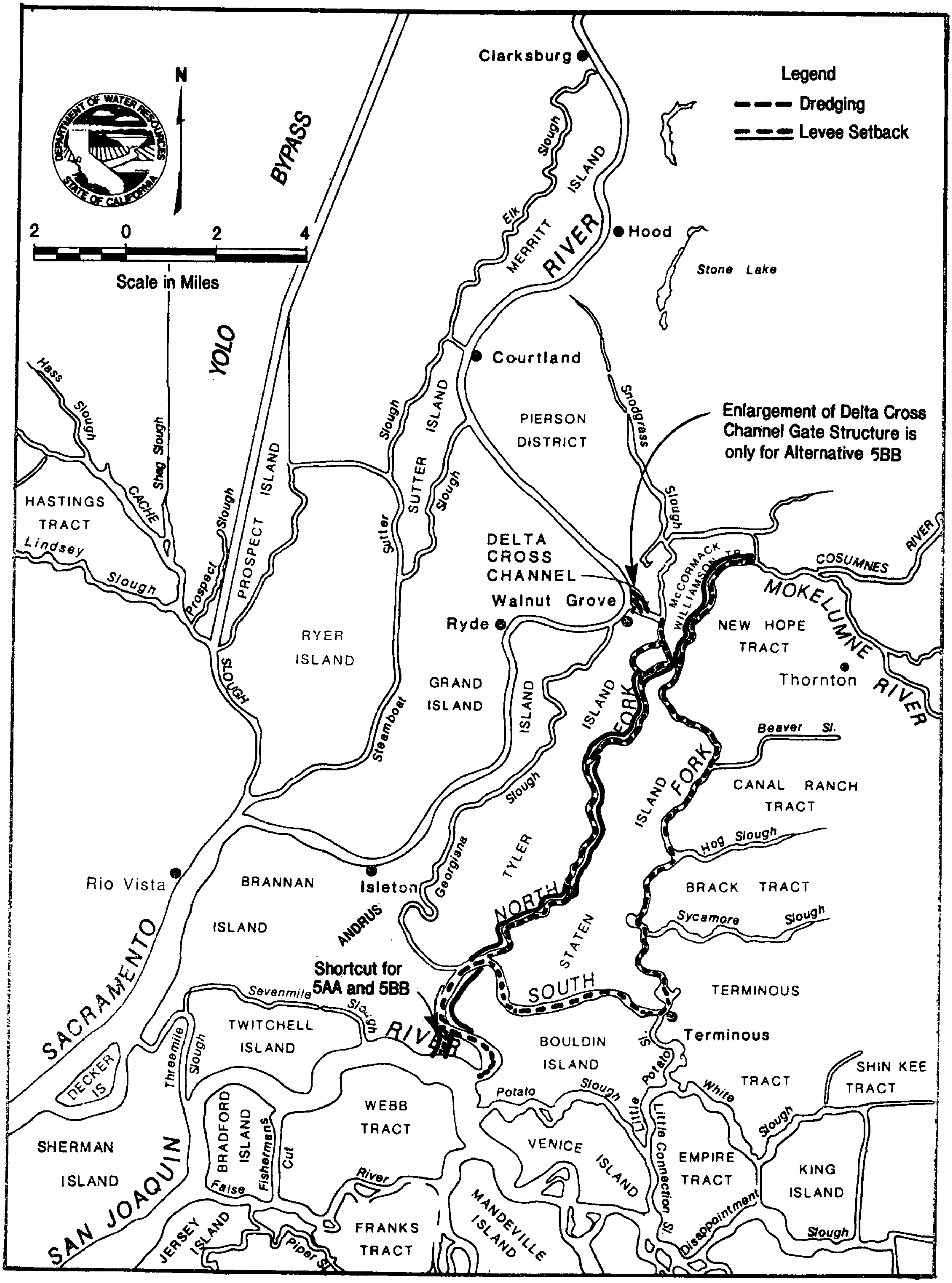


FIG. H-7

Table H-13

Alternative 5AA

Enlarge the North Fork and Dredge the South Fork and Enlarge the Delta Cross Channel Gate Structure plus Shortcut through Andrus Island

Item	unit	Reach 1	Reach 2	Reach 4a	Reach 4b	Reach 7	Reach 8	Reach 9	Andrus Cut	Reach 11	Quantity	Unit Cost	Item Cost
Excavate Existing Channel	CY	333,600	2,761,000	294,962	470,962	754,517	0	2,266,557		2,339,000	9,220,598	$4.00	$36,882,000
Reinforce Existing Levee	CY	115,703	154,200	14,814	14,814	25,925	35,592	50,000		233,000	644,048	$3.00	$1,932,000
Excavate New Channel	CY	4,403,111			448,296		1,111,111	1,811,462	206,000	81,100	8,061,080	$2.80	$22,571,000
Berm Embankment using Channel Excavation	CY				29,629		18,518	812,456	222,300	527,800	1,610,703	$3.00	$4,832,000
Levee Embankment using Channel Excavation	CY	641,866						81,000	206,000	414,500	1,343,366	$1.00	$1,343,000
Levee Embankment using imported borrow	CY				139,777		125,722	4,414,000	866,500	414,500	5,960,499	$7.00	$41,723,000
Geotextile (under embnk.)	SF		1,665,400				474,000	9,013,600	1,230,000	1,228,250	13,611,250	$0.25	$3,403,000
Riprap	Ton	272,232	101,365	25,380	50,760	18,637	45,380	803,072	32,600	79,000	1,428,426	$15.00	$21,426,000
Bedding (6" thick)	Ton	107,653	29,283	7,360	14,664	5,404	13,109	242,665	10,872	31,590	462,600	$14.00	$6,476,000
Geotextile under bedding	SF	3,329,718	901,019	225,600	451,200	165,773	403,377	7,725,086	362,240	1,053,000	14,617,013	$0.25	$3,654,000
Aggregate Base	Ton	12,320			2,240		2,240	70,280	27,000	3,000	117,080	$25.00	$2,927,000
Clearing and Grubbing	LS	150	91		59	18	99	483	60	27	987	$700.00	$691,000
Subtotal-1													$147,860,000
Miscellaneous 20%													$29,572,000
Subtotal-2													$177,432,000
Land Acquisition	AC	210						690	69	72	1,041	$2,000.00	$2,082,000
Utilities	LS	$85,000	$215,000		$72,000		$190,000	$113,000					$675,000
Bridges	LS						$500,000	$7,924,000	$3,000,000				$11,424,000
Subtotal-3													$191,613,000
S.O. plus Contingencies 35%													$67,065,000
Total Cost													$258,678,000

Table H-14

Alternative 5BB

Enlarge the North Fork and Dredge the South Fork and Enlarge the Delta Cross Channel Gate Structure plus Shortcut Through Andrus Island

Item	unit	Reach 1	Reach 2	Reach 4a	Reach 4b	Reach 7	Reach 8	Reach 9	Andrus Cut	Reach 11	Quantity	Unit Cost	Item Cost
Excavate Existing Channel	CY	333,600	2,761,000	294,962	470,962	754,517	0	2,266,557		2,339,000	9,220,598	$4.00	$36,882,000
Reinforce Existing Levee	CY	115,703	154,200	14,814	14,814	25,925	35,592	50,000		233,000	644,048	$3.00	$1,932,000
Excavate New Channel	CY	4,403,111			448,296		1,111,111	1,811,462	206,000	81,100	8,061,080	$2.80	$22,571,000
Berm Embankment using Channel Excavation	CY				29,629		18,518	812,456	222,300	527,800	1,610,703	$3.00	$4,832,000
Levee Embankment using Channel Excavation	CY	641,866						81,000	206,000	414,500	1,343,366	$1.00	$1,343,000
Levee Embankment using imported borrow	CY				139,777		125,722	4,414,000	866,500	414,500	5,960,499	$7.00	$41,723,000
Geotextile (under embnk.)	SF		1,665,400				474,000	9,013,600	1,230,000	1,228,250	13,611,250	$0.25	$3,403,000
Riprap	Ton	272,232	101,365	25,380	50,760	18,637	45,380	803,072	32,600	79,000	1,428,426	$15.00	$21,426,000
Bedding (6" thick)	Ton	107,653	29,283	7,360	14,664	5,404	13,109	242,665	10,872	31,590	462,600	$14.00	$6,476,000
Geotextile under bedding	SF	3,329,718	901,019	225,600	451,200	165,773	403,377	7,725,086	362,240	1,053,000	14,617,013	$0.25	$3,654,000
Aggregate Base	Ton	12,320			2,240		2,240	70,280	27,000	3,000	117,080	$25.00	$2,927,000
Clearing and Grubbing	LS	150	91		59	18	99	483	60	27	987	$700.00	$691,000
Enlarge Delta Cross Channel Gate Structure													$18,612,000
Subtotal-1													$166,472,000
Miscellaneous 20%													$33,294,000
Subtotal-2													$199,766,000
Land Acquisition	AC	210						690	69	72	1,041	$2,000.00	$2,082,000
Utilities	LS	$85,000	$215,000		$72,000		$190,000	$113,000					$675,000
Bridges	LS						$500,000	$7,924,000	$3,000,000				$11,424,000
Subtotal-3													$213,947,000
S.O. plus Contingencies 35%													$74,881,000
Total Cost													$288,828,000

Alternative 6A and 6B

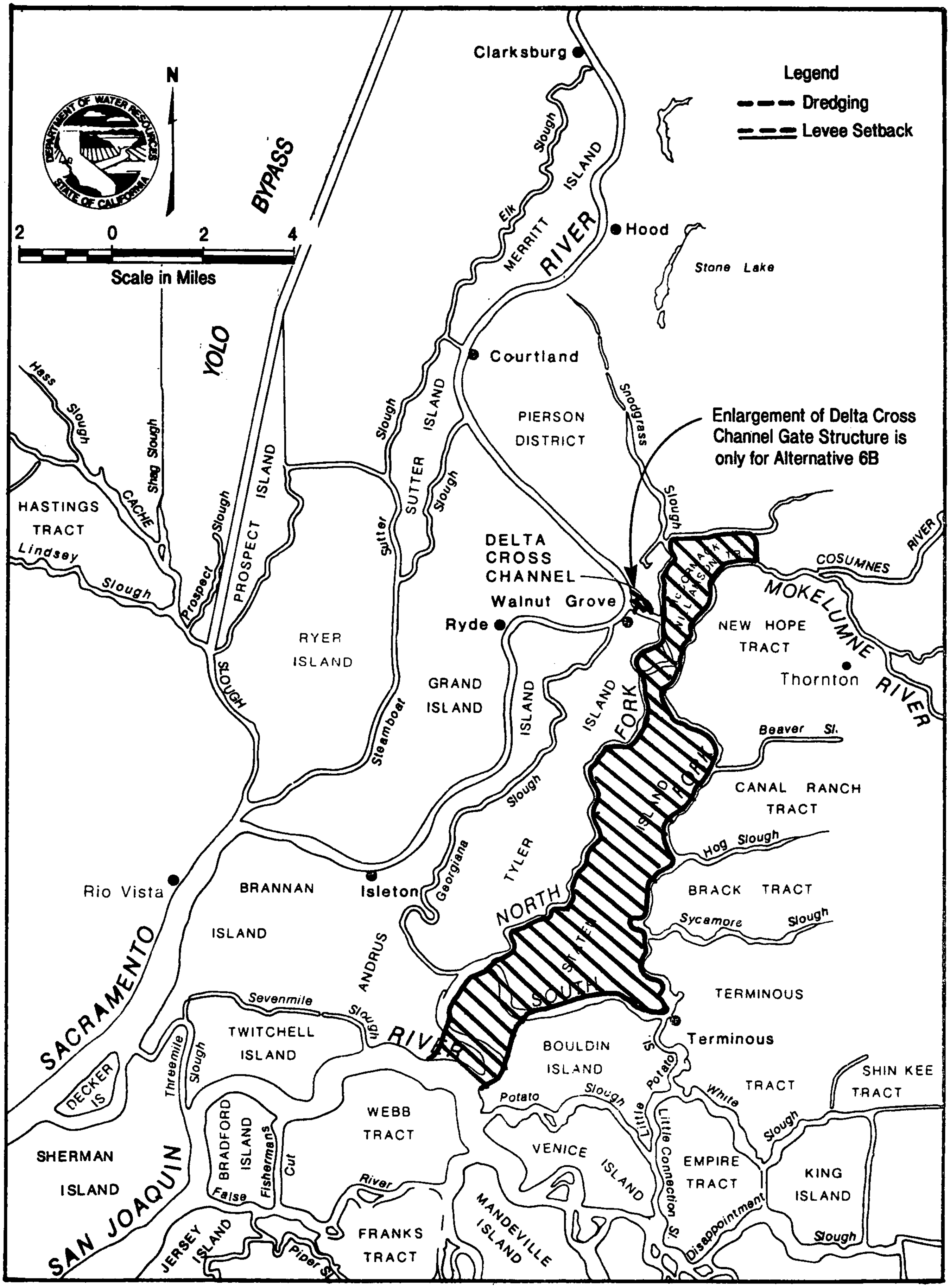


FIG. H-8

Table H-15
Alternative 6A
Create An Island Floodway

Item	Unit	McCormack-Williamson Tract	Dead Horse Island	Staten Island	Boulin Island	Andrus Island	Total Quantity	Unit Cost	Cost
Remove Riprap	Tons	30,000	29,935	19,620	35,721	40,752	156,028	$7.50	$1,170,210
Remove Levee	CY	230,000	337,296	262,073	984,533	1,123,200	2,937,102	$4.00	$11,748,408
Riprap	Tons	300,000	31,695	1,458,308	83,828	70,402	1,944,233	$15.00	$29,163,495
Bedding (6-in. thick)	Tons	84,600	8,943	411,780	23,656	19,867	548,846	$14.00	$7,683,844
Geotextile (bedding)	SF	2,576,000	272,453	9,276,039	744,993	625,800	13,495,285	$0.25	$3,373,821
Embankment	CY			473,257	1,200,000	919,146	2,592,403	$7.00	$18,146,821
Sub-base	Tons			7,486			7,486	$15.00	$112,290
Agg. Base--Class 2	Tons			7,486			7,486	$25.00	$187,150
Asiphalt Surfacing	tons			3,465			3,465	$50.00	$173,250
Subtotal -1									$71,759,289
Miscellaneous 20%									$14,351,858
Subtotal -2									$86,111,147
'Weirs	LS			14,160,000			14,160,000		$14,160,000
Bridge	LS			1,745,000	28,560,000		30,305,000		$30,305,000
Utilities	LS								$9,135,000
Marina Remove & Relocate	LS	26,000	150,000	5,000,000	250,000	8,114,000	13,540,000		$13,540,000
Land Acquisition/ROW	LS	2,648,000	358,000	13,608,000	1,793,000	13,744,000	32,151,000		$32,151,000
Subtotal -3									$185,402,147
S.O. plus Contingencies 35%									$64,890,751
Total Cost									$250,000,000

Table H-16
Alternative 6B
Create an Island Floodway and
Enlarge Delta Cross Channel Gate Structure

Item	Unit	McCormack-Williamson Tract	Dead Horse Island	Staten Island	Boulin Island	Andrus Island	Total Quantity	Unit Cost	Cost
Remove Riprap	Tons	30,000	29,935	19,620	35,721	40,752	156,028	$7.50	$1,170,210
Remove Levee	CY	230,000	337,296	262,073	984,533	1,123,200	2,937,102	$4.00	$11,748,408
Riprap	Tons	300,000	31,695	1,458,308	83,828	70,402	1,944,233	$15.00	$29,163,495
Bedding (6-in. thick)	Tons	84,600	8,943	411,780	23,656	19,867	548,846	$14.00	$7,683,844
Geotextile (bedding)	SF	2,576,000	272,453	9,276,039	744,993	625,800	13,495,285	$0.25	$3,373,821
Embankment	CY			473,257	1,200,000	919,146	2,592,403	$7.00	$18,146,821
Sub-base	Tons			7,486			7,486	$15.00	$112,290
Agg. Base--Class 2	Tons			7,486			7,486	$25.00	$187,150
Asiphalt Surfacing	tons			3,465			3,465	$50.00	$173,250
Enlarge Delta Cross C hannel	LS								$18,612,000
Subtotal -1									$90,371,289
Miscellaneous 20%									$18,074,258
Subtotal -2									$108,445,547
'Weirs	LS			14,160,000			14,160,000		$14,160,000
Bridge	LS			1,745,000	28,560,000		30,305,000		$30,305,000
Utilities	LS								$9,135,000
Marina Remove & Relocate	LS	26,000	150,000	5,000,000	250,000	8,114,000	13,540,000		$13,540,000
Land Acquisition/ROW	LS	2,648,000	358,000	13,608,000	1,793,000	13,744,000	32,151,000		$32,151,000
Subtotal -3									$207,736,547
S.O. plus Contingencies 35%									$72,707,791
Total Cost									$280,000,000

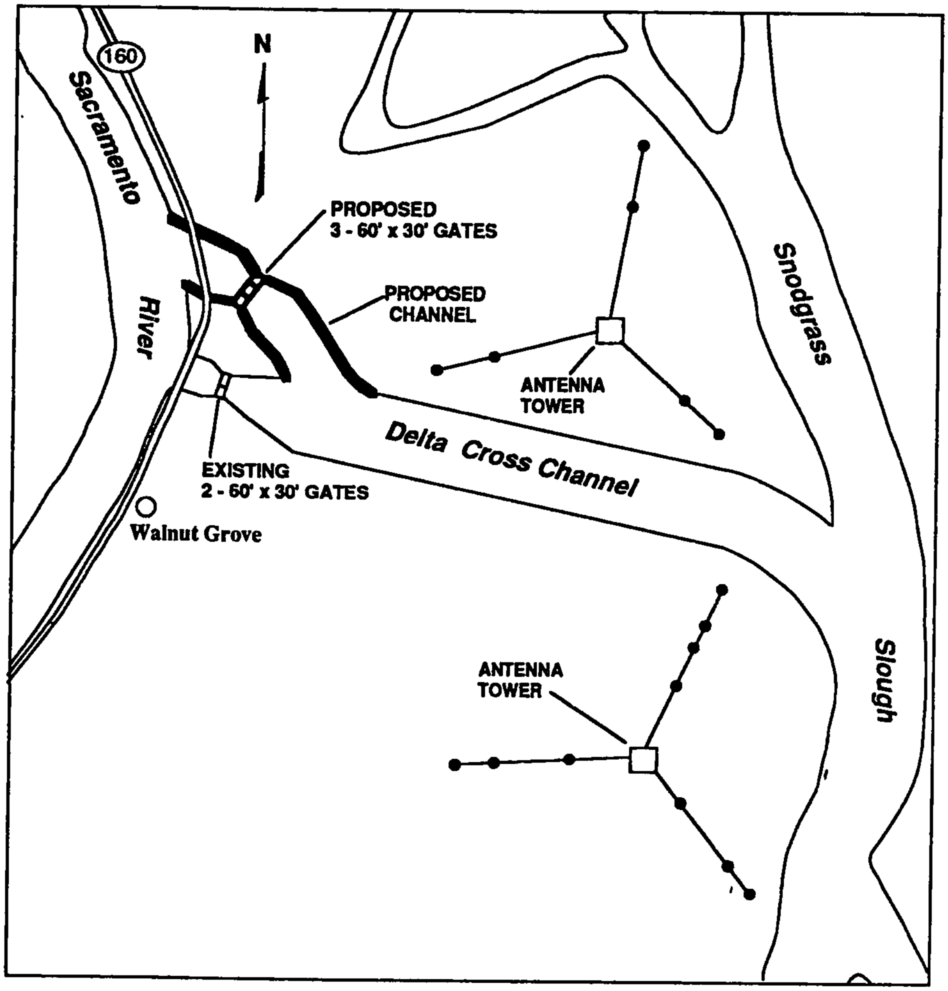


FIGURE H-9
PROPOSED PROJECT LAYOUT
ENLARGED DELTA CROSS CHANNEL GATE STRUCTURE
(A COMPONENT OF ALTERNATIVES 2B, 3B, 4B, 5B & 6B)

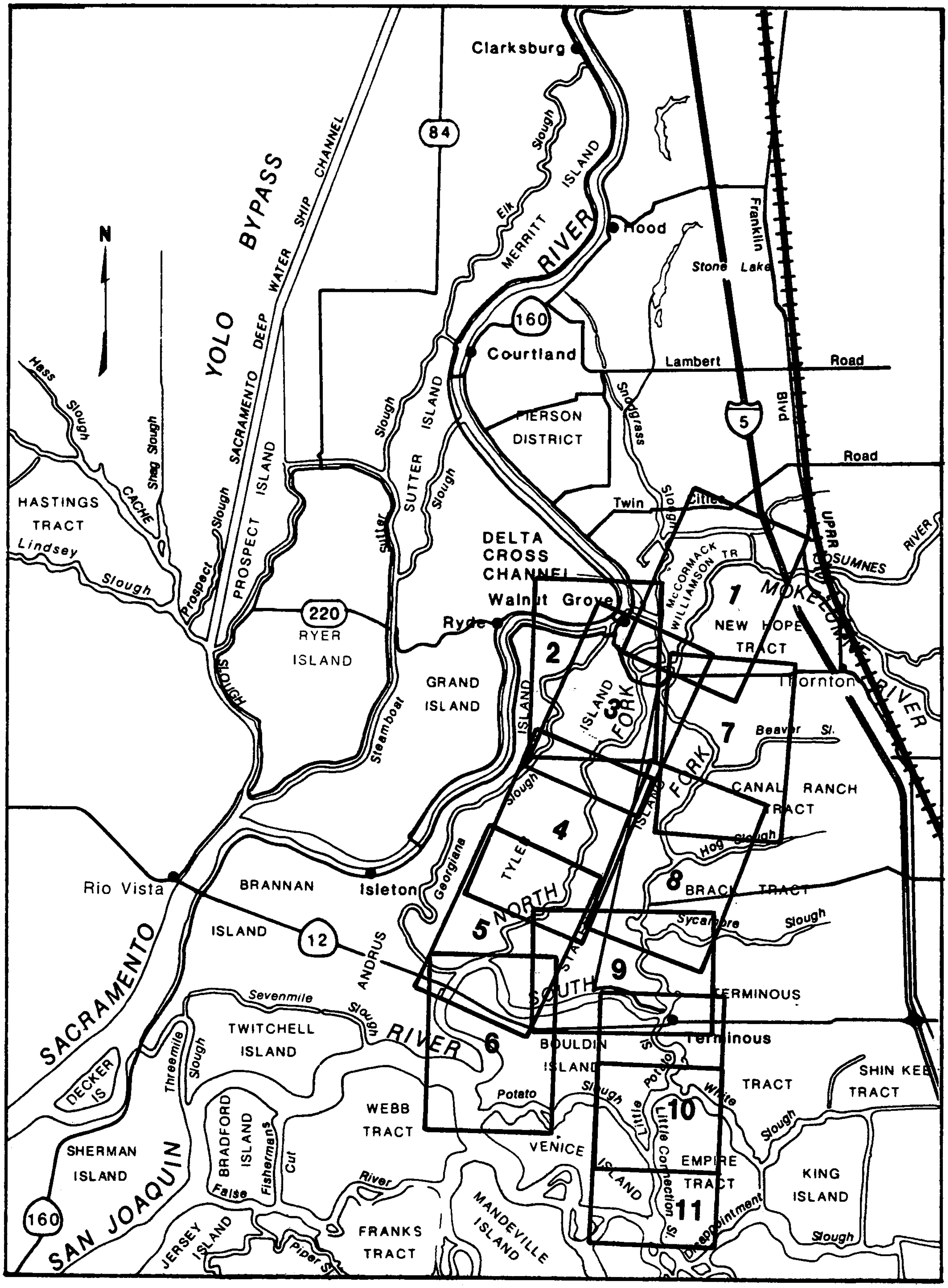
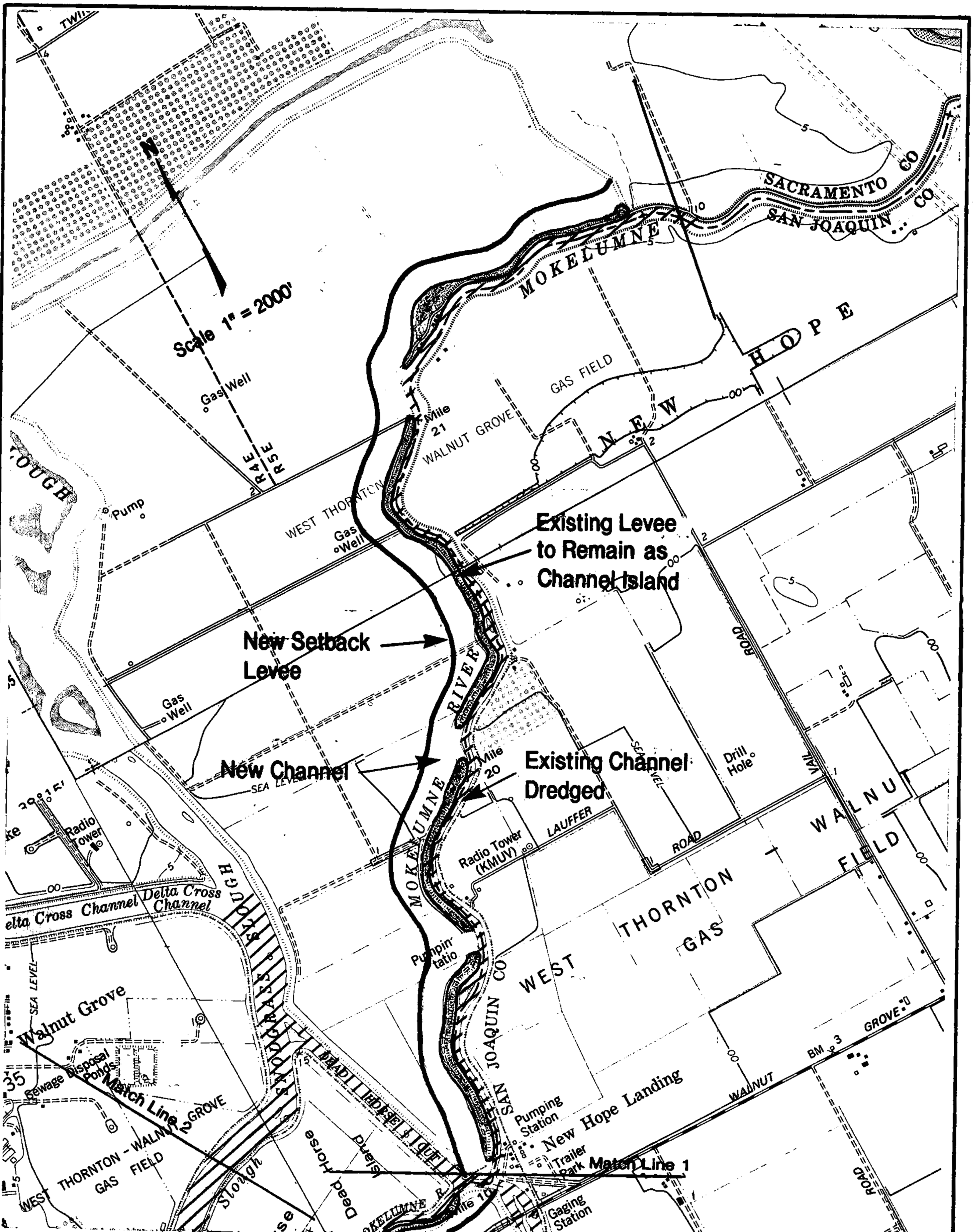


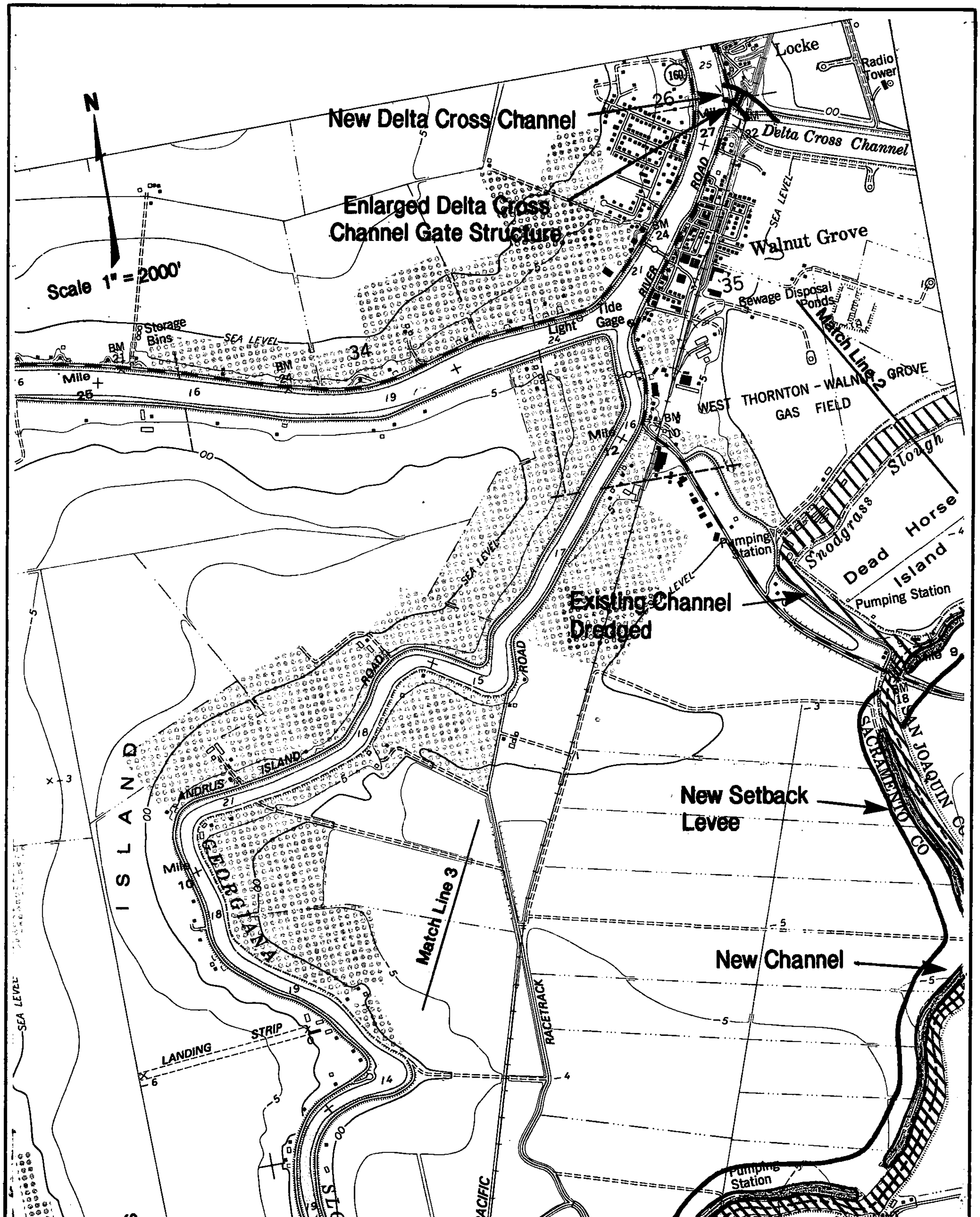
Fig. H-10 **Preferred Alternative (5B) Area of Improvements** Index Sheet



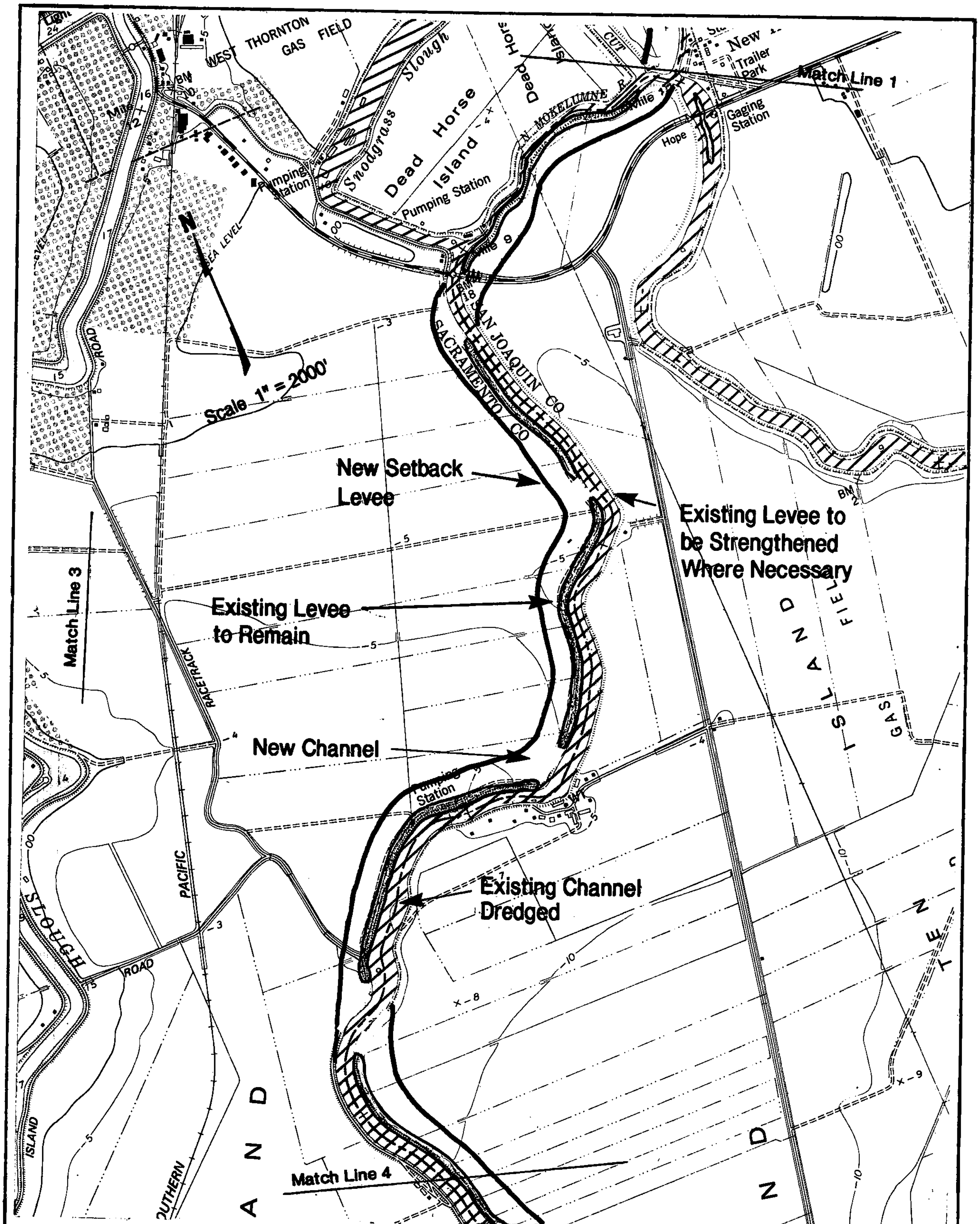
North Delta Program Preferred Alternative Proposed Setback Levee Alignment
Mokelumne River

Fig. H-11

1 of 11

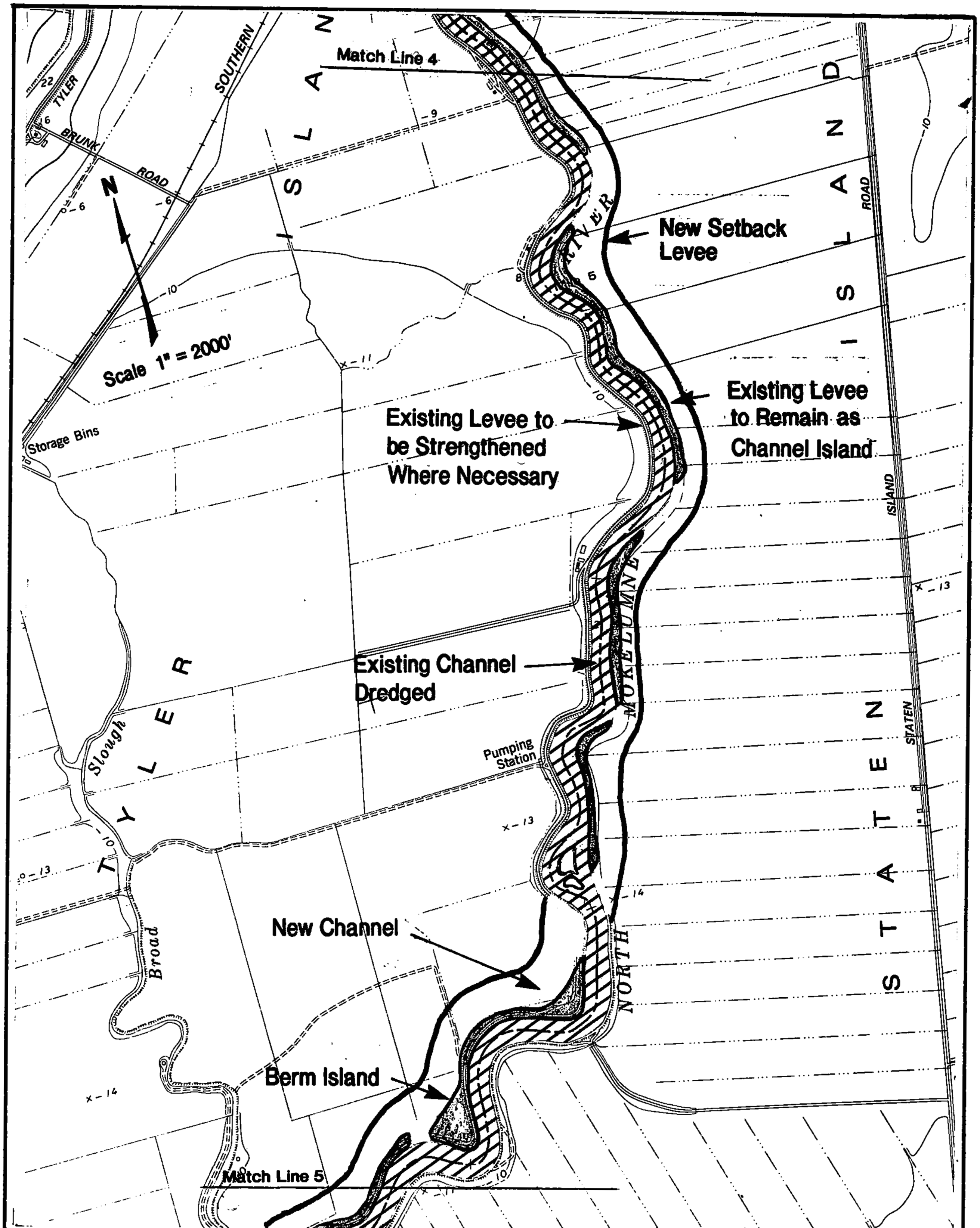


North Delta Program Preferred Alternative Proposed Setback Levee Alignment



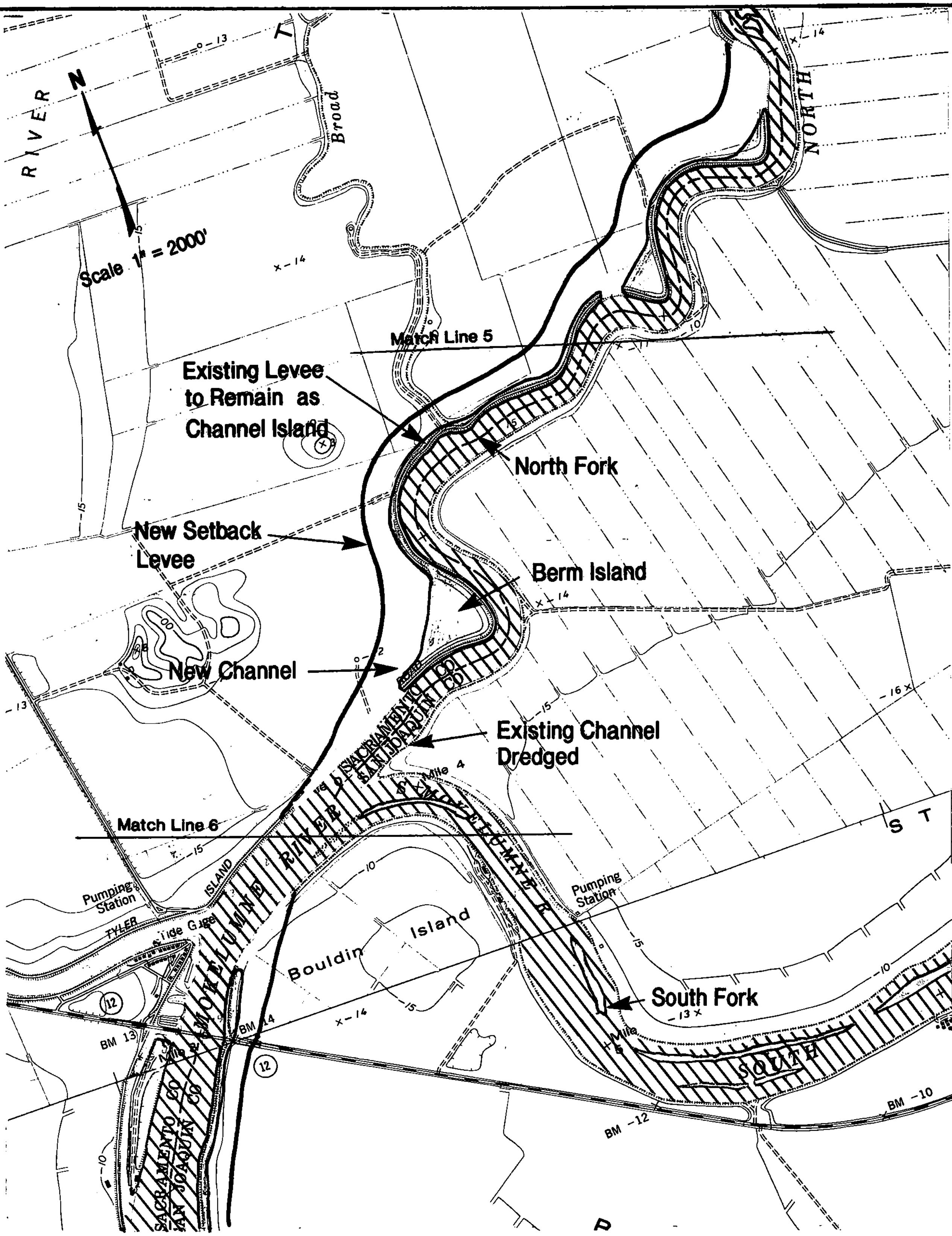
North Delta Program Preferred Alternative Proposed Setback Levee Alignment
North Fork Mokelumne River

Fig. H-13

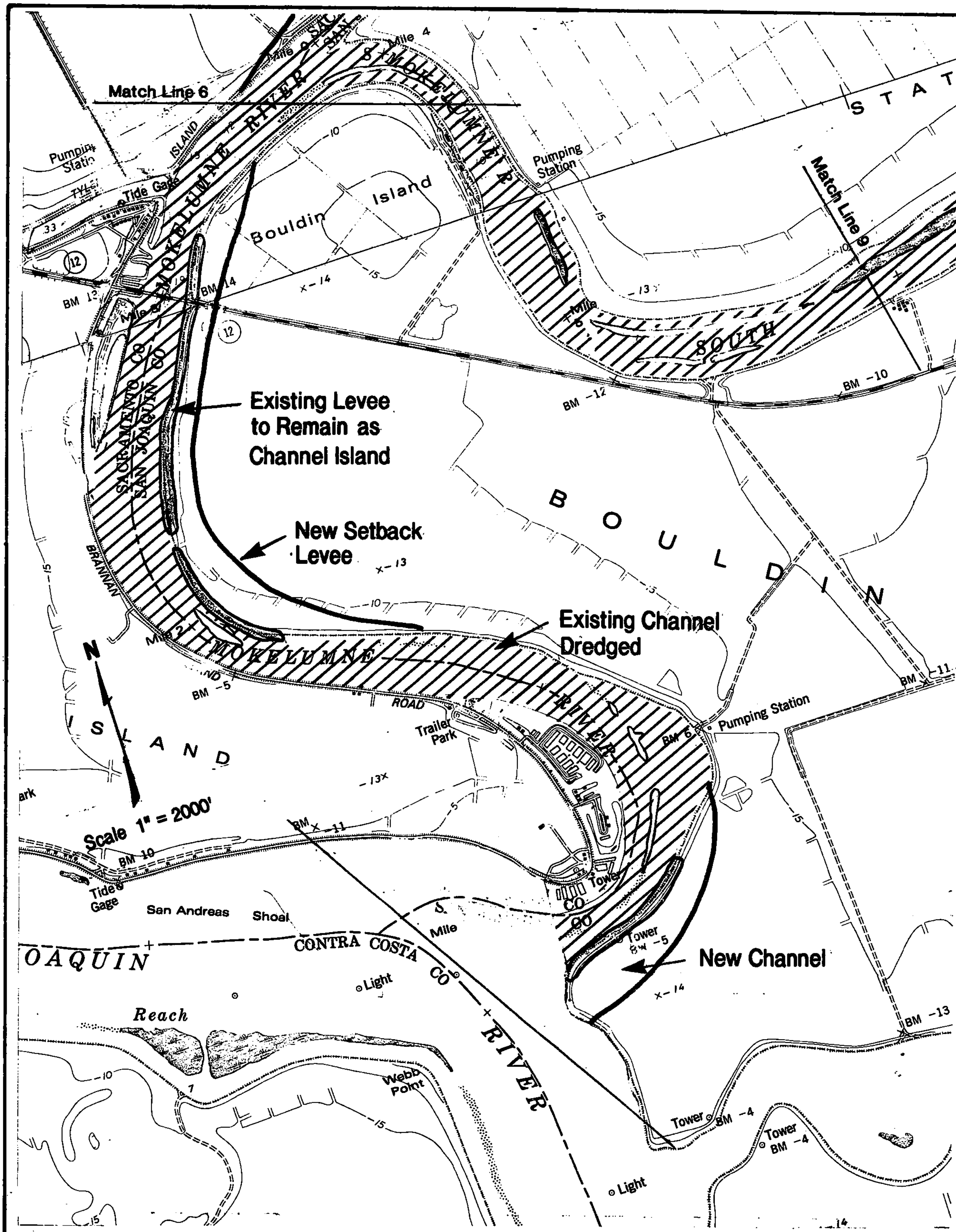


North Delta Program Preferred Alternative Proposed Setback Levee Alignment
North Fork Mokelumne River

Fig. H-14

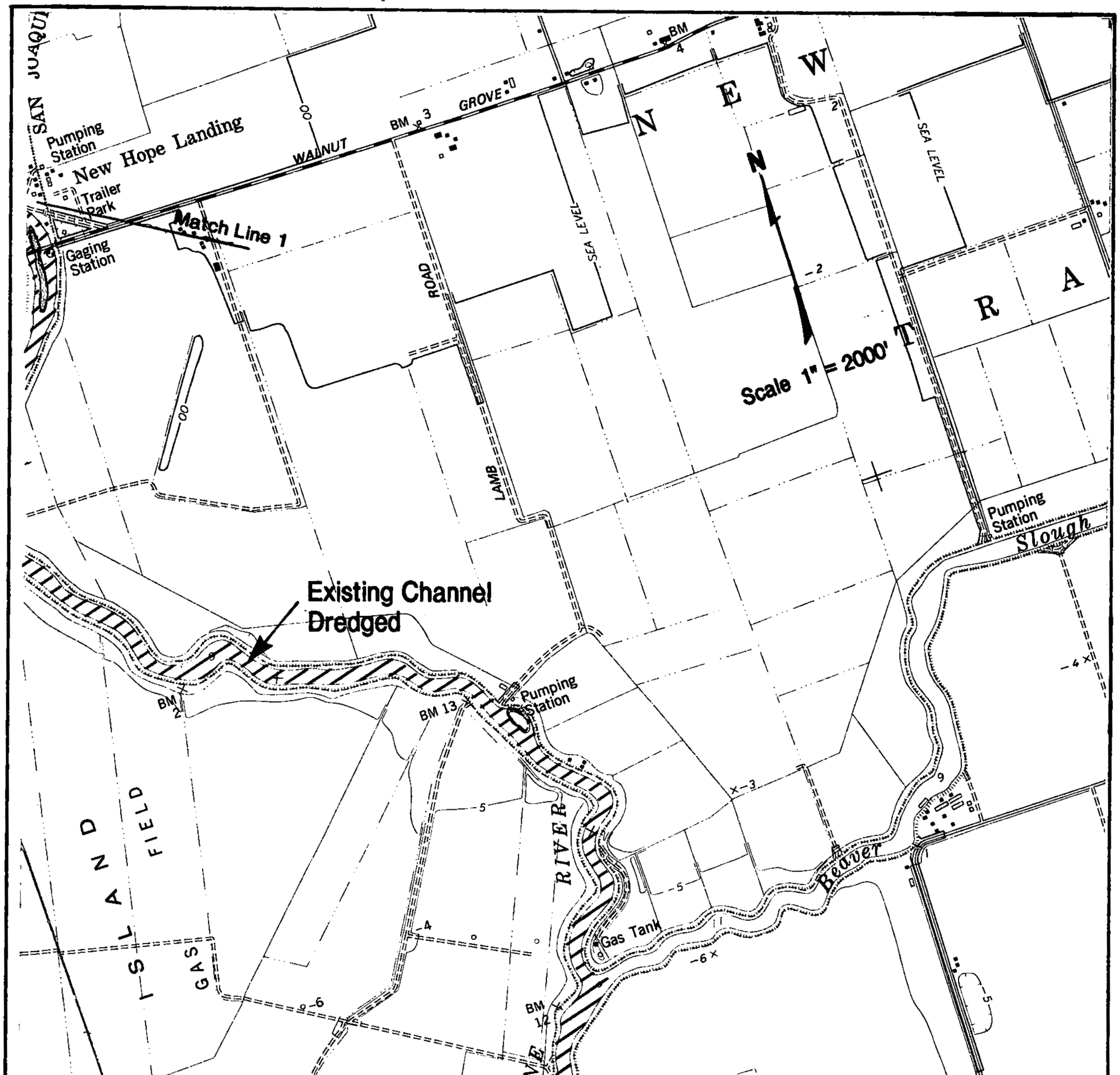


North Delta Program Preferred Alternative Proposed Setback Levee Alignment
North and South Fork Mokelumne River



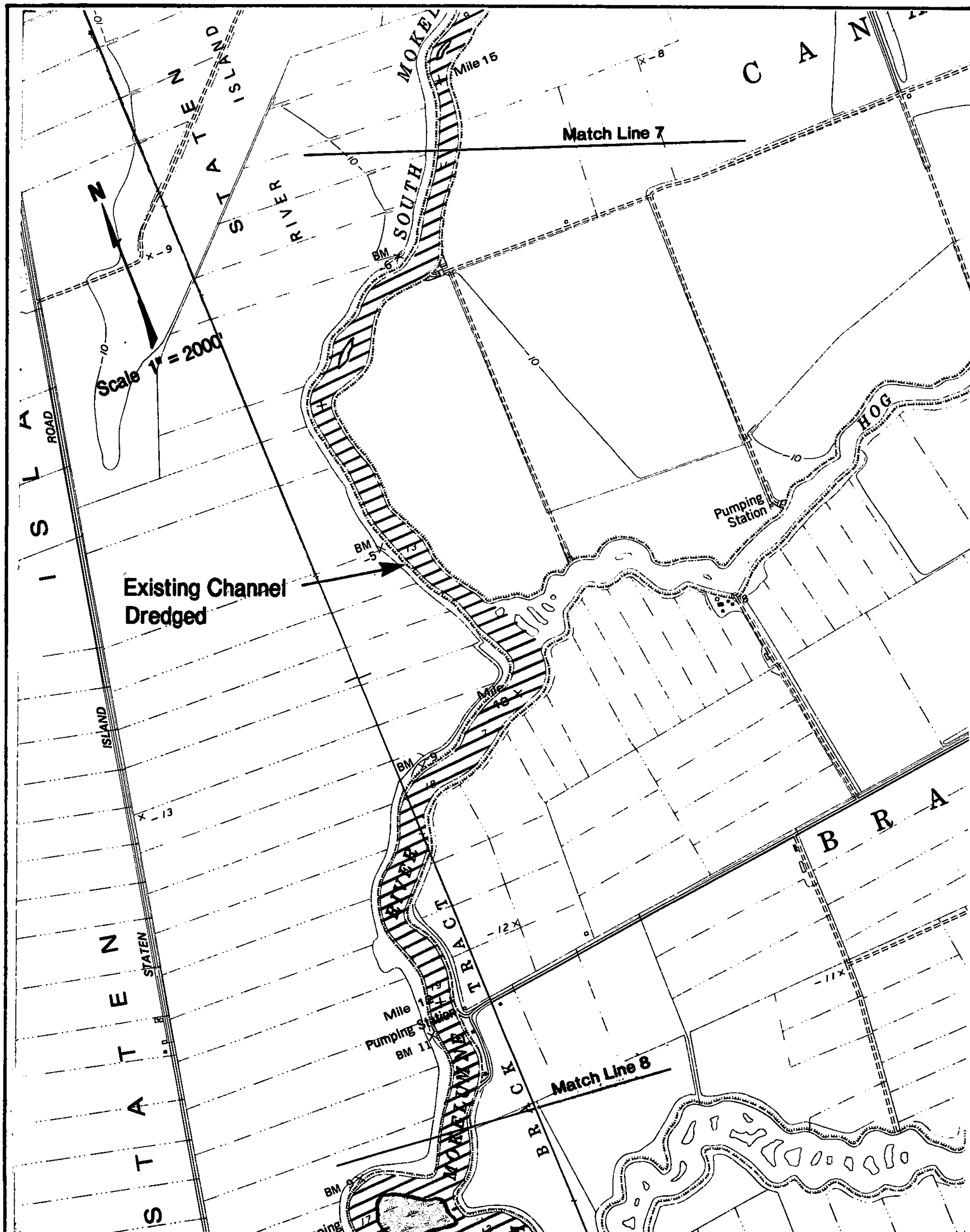
North Delta Program Preferred Alternative Proposed Setback Levee Alignment
South Fork Mokelumne River

Fig. H-16

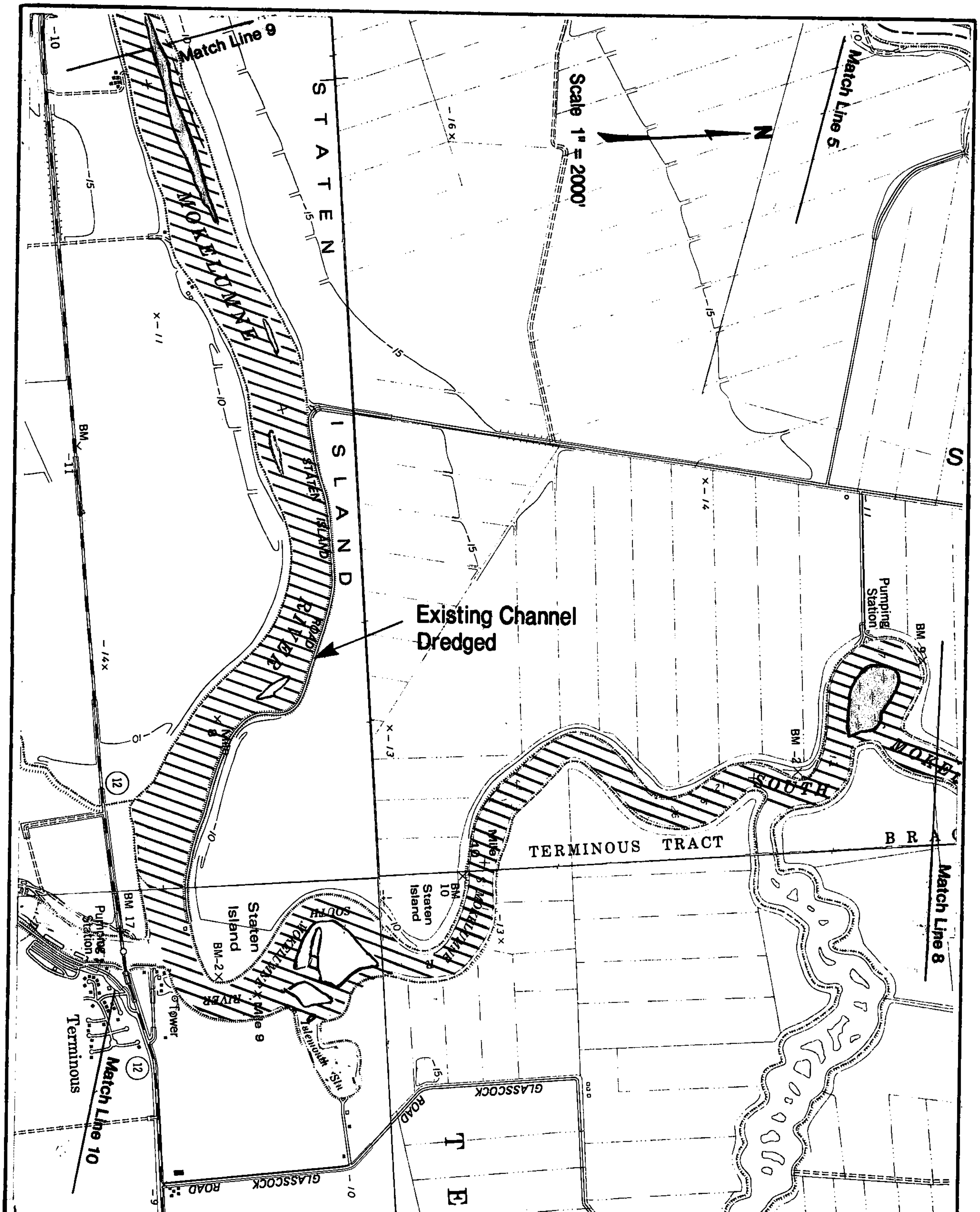


North Delta Program Preferred Alternative Proposed Setback Levee Alignment
South Fork Mokelumne River

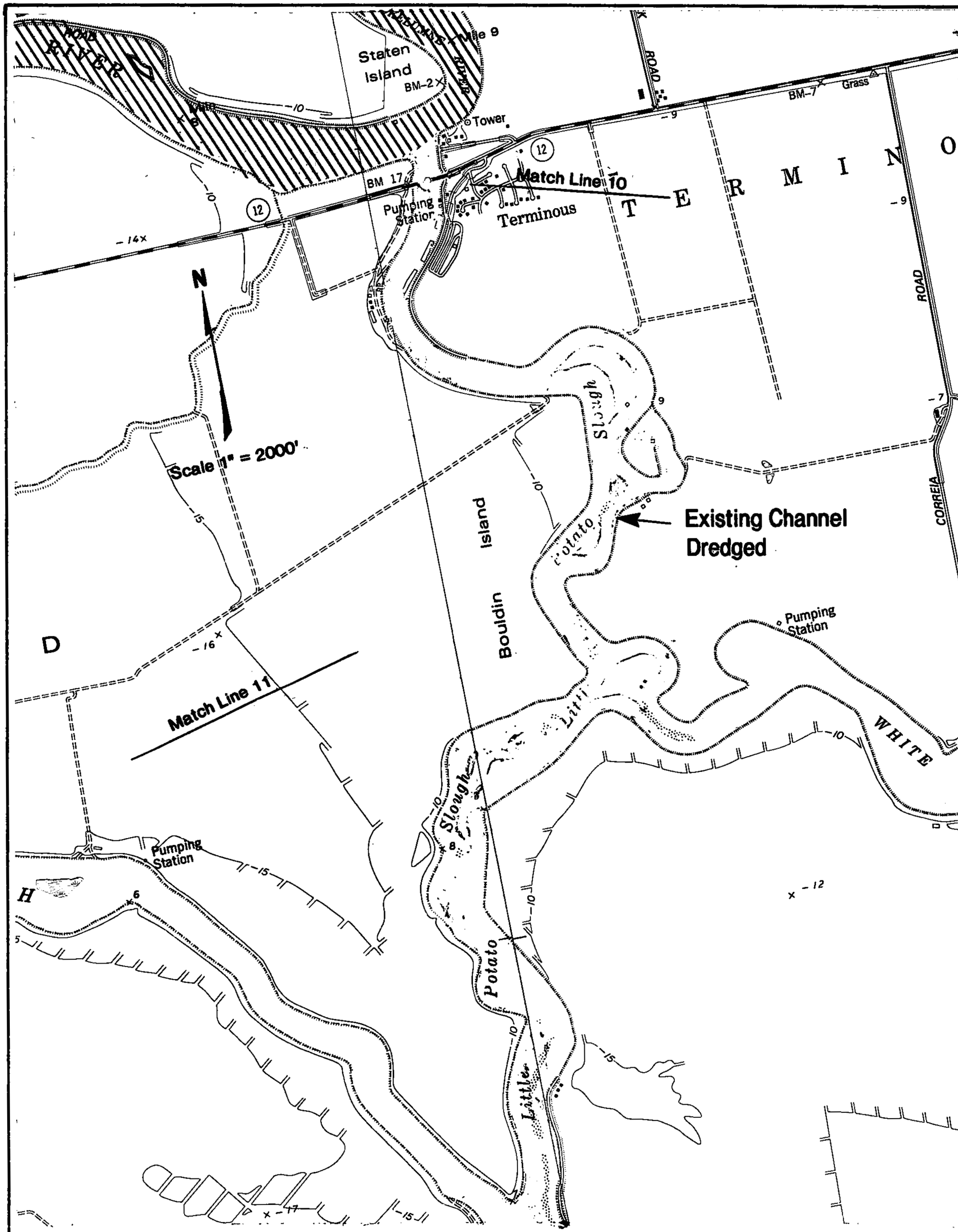
Fig. H-17



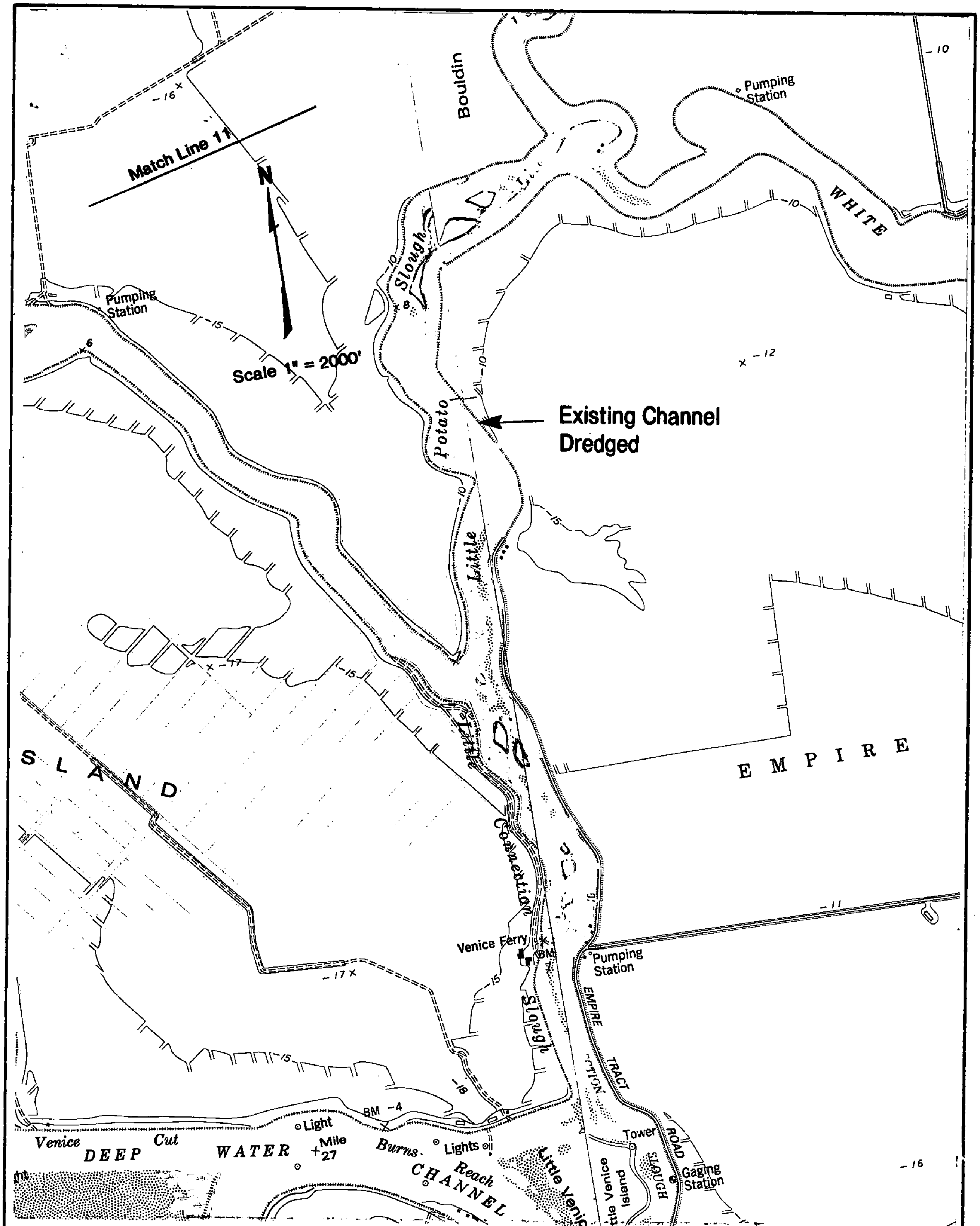
North Delta Program Preferred Alternative Proposed Setback Levee Alignment
South Fork Mokelumne River



North Delta Program Preferred Alternative Proposed Setback Levee Alignment
South Fork Mokelumne River



North Delta Program Preferred Alternative Proposed Setback Levee Alignment
Little Potato Slough



North Delta Program Preferred Alternative Proposed Setback Levee Alignment
Little Potato Slough

Fig. H-21

APPENDIX I
PRELIMINARY DREDGE MATERIAL TEST RESULTS

APPENDIX I
PRELIMINARY DREDGE MATERIAL TEST RESULTS

The NDP currently plans to use dredge material excavated out of north Delta channels for levee construction or wildlife enhancement. Prior to dredging, the Department must receive an approved Section 404 permit from the Department of the Army and a certification or waiver of certification from the Regional Water Quality Control Board, Central Valley Region (RWQCB, CVR) stating that the proposed project will not violate state water quality standards. Approval from these agencies would be based on the types and quantities of toxics present at potential dredge sites.

There has not been any known in-depth testing of north Delta channel sediment, therefore a broad scan survey of toxic chemicals and metals such as chlorinated pesticides, PCBs, mercury and tributyltin was conducted. The Department felt that it would be inappropriate to conduct a large study without consulting those agencies that would be involved in the EIR process. Therefore, the initial survey was designed to gather survey information which could be used as a basis to design a thorough sampling program.

The field sampling was conducted by boat on March 28, 1990. Six sites were selected with each site representing one of the following criteria:

- Near a marina,
- Adjacent to an agricultural drainage pump,
- In a 'clear' area.

All samples were taken from mid-stream by a clam-shell bucket.

Pace Laboratories and the Department's Soil and Concrete Laboratory received the dredge material samples on March 29, 1990. Pace Laboratory conducted the toxic chemical and metals testing while the Department's Soil and Concrete Laboratory conducted a soil classification test. Results of both analysis are included in this appendix.

Based on RWQCB,CVR, DHS, and DFG comments from the workshop the Department conducted on June 13, 1990, the Department is currently drafting a workplan outlining the following:

- toxic chemicals and metals that will be tested for,
- location of test sites,
- depths below channel bed that sediment samples will be taken
- laboratory analysis procedures,
- detection limits
- drainage water testing from the dredge material,
- drainage water that may leach into the ground water,
- drainage water that enters back into the channel,
- water column toxicity during and after dredging,

The draft workplan will be submitted to RWQCB,CVR for review prior to finalization and implementation.

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REPORT OF LABORATORY ANALYSIS

Date Data Received: 5/11/90
Lab Analysis Book Ck: UW
Chain of Custody Ck: UW
Computer Entry Date: 5/29/90
Invoice Received Date:
Copies Made:

To Files:
Notes:

May 01, 1990

Mr. Bruce Agee
Department of Water Resources, Central
3251 S. Street
Sacramento, CA 95816

RE: PACE Project No. 400329.500
Calif.DWR Central

Dear Mr. Agee:

Enclosed is the report of organotin results for samples received March 29, 1990. This supplements the report issued April 19, 1990.

If you have any questions concerning this report, please feel free to contact us.

Sincerely,

Stephen F. Nackord
Director, Sampling and Analytical Services

Enclosures

11 Digital Drive
Novato, CA 94949
TEL: 415-883-6100
FAX: 415-883-2673

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REPORT OF LABORATORY ANALYSIS

Department of Water Resources, Central
3251 S. Street
Sacramento, CA 95816

May 01, 1990
PACE Project
Number: 400329500
PACE WP Number: WPPLAB 1294

Attn: Mr. Bruce Agee

Calif.DWR Central

PACE Sample Number:			733030	733040	733050
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
Parameter	Units	MDL	CQ 0169	CQ 0170	CQ 0171
SUBCONTRACT ANALYSIS					
ORGANOTIN COMPOUNDS					
Monobutyl Tin	ug/kg dry	1	ND	ND	ND
Dibutyl Tin	ug/kg dry	1	ND	ND	0.64 TRAC
Tributyl Tin	ug/kg dry	1	5.4	3.3	ND
Tetrabutyl Tin	ug/kg dry	1	ND	ND	ND

MDL Method Detection Limit
ND Not detected at or above the MDL.

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REPORT OF LABORATORY ANALYSIS

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THE ASSURANCE OF QUALITY

May 01, 1990
PACE Project
Number: 400329500

Calif.DWR Central

PACE Sample Number:			733060	733070	733080
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
Parameter	Units	MDL	CQ 0172	CQ 0173	CQ 0174
SUBCONTRACT ANALYSIS					
ORGANOTIN COMPOUNDS					
Monobutyl Tin	ug/kg dry	1	ND	ND	2.3
Dibutyl Tin	ug/kg dry	1	4.1	1.5	3.7
Tributyl Tin	ug/kg dry	1	3.5	2.4	5.3
Tetrabutyl Tin	ug/kg dry	1	ND	ND	ND

MDL Method Detection Limit
ND Not detected at or above the MDL.

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REPORT OF LABORATORY ANALYSIS

Mr. Bruce Agee
Page 3

May 01, 1990
PACE Project
Number: 400329500

Calif.DWR Central

PACE Sample Number:			733090
Date Collected:			03/29/90
Date Received:			03/29/90
Parameter	Units	MDL	CQ 0175
SUBCONTRACT ANALYSIS			
ORGANOTIN COMPOUNDS			
Monobutyl Tin	ug/kg dry	1	0.82 TRACE
Dibutyl Tin	ug/kg dry	1	4.0
Tributyl Tin	ug/kg dry	1	4.2
Tetrabutyl Tin	ug/kg dry	1	ND

MDL Method Detection Limit
ND Not detected at or above the MDL.

The data contained in this report were obtained using EPA or other approved methodologies. All analyses were performed by me or under my supervision.

Stephen F. Nackord
Director, Sampling and Analytical Services

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Novato, CA 94949
TEL: 415-883-6100
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Date Data Received: 4/23/90
Lab Analysis Book Ck: [illegible]
Chain of Custody Ck: [illegible]
Computer Entry Date: 6/6/90
Invoice Received Date:
Copies Made:

To Files:
Notes:

April 19, 1990

Mr. Bruce Agee
Department of Water Resources, Central
3251 S. Street
Sacramento, CA 95816

RE: PACE Project No. 400329.500
Calif.DWR Central

Dear Mr. Agee:

Enclosed is the report of laboratory analyses for samples received March 29, 1990.

If you have any questions concerning this report, please feel free to contact us.

Sincerely,

Stephen Nackord

Stephen F. Nackord
Director, Sampling and Analytical Services

NOTE: The results for the organotin testing will be submitted when the results are received from the subcontractor.

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REPORT OF LABORATORY ANALYSIS

Mr. Bruce Agee
Page 2

April 19, 1990
PACE Project
Number: 400329500

Calif.DWR Central

PACE Sample Number:			733030	733040	733050
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
Parameter	Units	MDL	CQ 0169	CQ 0170	CQ 0171
ORGANIC ANALYSIS					
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)					
Bis(2-chloroisopropyl) ether	ug/kg	300	ND	ND	ND
N-Nitrosodipropylamine	ug/kg	300	ND	ND	ND
Hexachloroethane	ug/kg	300	ND	ND	ND
Nitrobenzene	ug/kg	300	ND	ND	ND
Isophorone	ug/kg	300	ND	ND	ND
Bis(2-chloroethoxy)methane	ug/kg	300	ND	ND	ND
1,2,4-Trichlorobenzene	ug/kg	300	ND	ND	ND
Naphthalene	ug/kg	300	ND	ND	ND
4-Chloroaniline	ug/kg	300	ND	ND	ND
Hexachlorobutadiene	ug/kg	300	ND	ND	ND
2-Methylnaphthalene	ug/kg	300	ND	ND	ND
Hexachlorocyclopentadiene	ug/kg	300	ND	ND	ND
2-Chloronaphthalene	ug/kg	300	ND	ND	ND
2-Nitroaniline	ug/kg	1500	ND	ND	ND
Dimethylphthalate	ug/kg	300	ND	ND	ND
Acenaphthylene	ug/kg	300	ND	ND	ND
2,6-Dinitrotoluene	ug/kg	300	ND	ND	ND
3-Nitroaniline	ug/kg	1500	ND	ND	ND
Acenaphthene	ug/kg	300	ND	ND	ND
Dibenzofuran	ug/kg	300	ND	ND	ND
2,4-Dinitrotoluene	ug/kg	300	ND	ND	ND
Diethylphthalate	ug/kg	300	ND	ND	ND
Fluorene	ug/kg	300	ND	ND	ND
4-Nitroaniline	ug/kg	1500	ND	ND	ND
4-Chlorophenylphenylether	ug/kg	300	ND	ND	ND
N-Nitrosodiphenylamine	ug/kg	300	ND	ND	ND
1,2-Diphenylhydrazine	ug/kg	300	ND	ND	ND
4-Bromophenylphenylether	ug/kg	300	ND	ND	ND
Hexachlorobenzene	ug/kg	300	ND	ND	ND

MDL Method Detection Limit
ND Not detected at or above the MDL.

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April 19, 1990
PACE Project Number: 400329500

Calif.DWR Central

PACE Sample Number:			733030	733040	733050
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
Parameter	Units	MDL	CQ 0169	CQ 0170	CQ 0171
ORGANIC ANALYSIS					
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)					
Phenanthrene	ug/kg	300	ND	ND	ND
Anthracene	ug/kg	300	ND	ND	ND
Di-n-butylphthalate	ug/kg	300	ND	ND	ND
Fluoranthene	ug/kg	300	ND	ND	ND
Benzidine	ug/kg	1500	ND	ND	ND
Pyrene	ug/kg	300	ND	ND	ND
Butylbenzylphthalate	ug/kg	300	ND	ND	ND
Benzo(a)anthracene	ug/kg	300	ND	ND	ND
3,3'-Dichlorobenzidine	ug/kg	600	ND	ND	ND
Chrysene	ug/kg	300	ND	ND	ND
Bis(2-ethylhexyl)phthalate	ug/kg	300	ND	ND	ND
Di-n-octylphthalate	ug/kg	300	ND	ND	ND
Benzo(b)fluoranthene	ug/kg	300	ND	ND	ND
Benzo(k)fluoranthene	ug/kg	300	ND	ND	ND
Benzo(a)pyrene	ug/kg	300	ND	ND	ND
Ideno(1,2,3-cd)pyrene	ug/kg	300	ND	ND	ND
Dibenzo(a,h)anthracene	ug/kg	300	ND	ND	ND
Benzo(g,h,i)perylene	ug/kg	300	ND	ND	ND
Phenol	ug/kg	300	ND	ND	ND
2-Chlorophenol	ug/kg	300	ND	ND	ND
2-Methylphenol	ug/kg	300	ND	ND	ND
4-Methylphenol	ug/kg	300	ND	ND	ND
2-Nitrophenol	ug/kg	300	ND	ND	ND
2,4-Dimethylphenol	ug/kg	300	ND	ND	ND
Benzoic Acid	ug/kg	1500	ND	ND	ND
2,4-Dichlorophenol	ug/kg	300	ND	ND	ND
4-Chloro-3-methylphenol	ug/kg	300	ND	ND	ND
2,4,6-Trichlorophenol	ug/kg	300	ND	ND	ND
2,4,5-Trichlorophenol	ug/kg	300	ND	ND	ND

MDL Method Detection Limit
ND Not detected at or above the MDL.

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April 19, 1990
PACE Project
Number: 400329500

Calif.DWR Central

PACE Sample Number:			733030	733040	733050
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
Parameter	Units	MDL	CQ 0169	CQ 0170	CQ 0171
ORGANIC ANALYSIS					
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)					
2,4-Dinitrophenol	ug/kg	1500	ND	ND	ND
4-Nitrophenol	ug/kg	1500	ND	ND	ND
2-Methyl-4,6-dinitrophenol	ug/kg	1500	ND	ND	ND
Pentachlorophenol	ug/kg	300	ND	ND	ND
alpha-BHC	ug/kg	300	ND	ND	ND
beta-BHC	ug/kg	300	ND	ND	ND
gamma-BHC	ug/kg	300	ND	ND	ND
delta-BHC	ug/kg	300	ND	ND	ND
Heptachlor	ug/kg	300	ND	ND	ND
Aldrin	ug/kg	300	ND	ND	ND
Heptachlor Epoxide	ug/kg	300	ND	ND	ND
Endosulfan I	ug/kg	300	ND	ND	ND
4,4'-DDE	ug/kg	1500	ND	ND	ND
Dieldrin	ug/kg	300	ND	ND	ND
Endrin	ug/kg	300	ND	ND	ND
Endosulfan II	ug/kg	300	ND	ND	ND
4,4'-DDD	ug/kg	300	ND	ND	ND
Endrin Aldehyde	ug/kg	1500	ND	ND	ND
4,4'-DDT	ug/kg	300	ND	ND	ND
Endosulfan Sulfate	ug/kg	1500	ND	ND	ND
Aroclor-1016	ug/kg	3000	ND	ND	ND
Aroclor-1221	ug/kg	3000	ND	ND	ND
Aroclor-1232	ug/kg	3000	ND	ND	ND
Aroclor-1242	ug/kg	3000	ND	ND	ND
Aroclor-1248	ug/kg	3000	ND	ND	ND
Aroclor-1254	ug/kg	3000	ND	ND	ND
Aroclor-1260	ug/kg	3000	ND	ND	ND
Nitrobenzene-d5 (Surrogate Recovery)			64%	57%	54%
2-Fluorobiphenyl (Surrogate Recovery)			84%	74%	75%

MDL Method Detection Limit
ND Not detected at or above the MDL.

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April 19, 1990
PACE Project
Number: 400329500

Calif.DWR Central

PACE Sample Number:			733060	733070	733080
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
Parameter	Units	MDL	CQ 0172	CQ 0173	CQ 0174
ORGANIC ANALYSIS					
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)					
Hexachloroethane	ug/kg	300	ND	ND	ND
Nitrobenzene	ug/kg	300	ND	ND	ND
Isophorone	ug/kg	300	ND	ND	ND
Bis(2-chloroethoxy)methane	ug/kg	300	ND	ND	ND
1,2,4-Trichlorobenzene	ug/kg	300	ND	ND	ND
Naphthalene	ug/kg	300	ND	ND	ND
4-Chloroaniline	ug/kg	300	ND	ND	ND
Hexachlorobutadiene	ug/kg	300	ND	ND	ND
2-Methylnaphthalene	ug/kg	300	ND	ND	ND
Hexachlorocyclopentadiene	ug/kg	300	ND	ND	ND
2-Chloronaphthalene	ug/kg	300	ND	ND	ND
2-Nitroaniline	ug/kg	1500	ND	ND	ND
Dimethylphthalate	ug/kg	300	ND	ND	ND
Acenaphthylene	ug/kg	300	ND	ND	ND
2,6-Dinitrotoluene	ug/kg	300	ND	ND	ND
3-Nitroaniline	ug/kg	1500	ND	ND	ND
Acenaphthene	ug/kg	300	ND	ND	ND
Dibenzofuran	ug/kg	300	ND	ND	ND
2,4-Dinitrotoluene	ug/kg	300	ND	ND	ND
Diethylphthalate	ug/kg	300	ND	ND	ND
Fluorene	ug/kg	300	ND	ND	ND
4-Nitroaniline	ug/kg	1500	ND	ND	ND
4-Chlorophenylphenylether	ug/kg	300	ND	ND	ND
N-Nitrosodiphenylamine	ug/kg	300	ND	ND	ND
1,2-Diphenylhydrazine	ug/kg	300	ND	ND	ND
4-Bromophenylphenylether	ug/kg	300	ND	ND	ND
Hexachlorobenzene	ug/kg	300	ND	ND	ND
Phenanthrene	ug/kg	300	ND	ND	ND
Anthracene	ug/kg	300	ND	ND	ND

MDL Method Detection Limit
ND Not detected at or above the MDL.

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Mr. Bruce Agee
Page 9

April 19, 1990
PACE Project
Number: 400329500

Calif.DWR Central

PACE Sample Number:			733060	733070	733080
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
Parameter	Units	MDL	CQ 0172	CQ 0173	CQ 0174
ORGANIC ANALYSIS					
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)					
Di-n-butylphthalate	ug/kg	300	ND	ND	ND
Fluoranthene	ug/kg	300	ND	ND	ND
Benzidine	ug/kg	1500	ND	ND	ND
Pyrene	ug/kg	300	ND	ND	ND
Butylbenzylphthalate	ug/kg	300	ND	ND	ND
Benzo(a)anthracene	ug/kg	300	ND	ND	ND
3,3'-Dichlorobenzidine	ug/kg	600	ND	ND	ND
Chrysene	ug/kg	300	ND	ND	ND
Bis(2-ethylhexyl)phthalate	ug/kg	300	ND	ND	ND
Di-n-octylphthalate	ug/kg	300	ND	ND	ND
Benzo(b)fluoranthene	ug/kg	300	ND	ND	ND
Benzo(k)fluoranthene	ug/kg	300	ND	ND	ND
Benzo(a)pyrene	ug/kg	300	ND	ND	ND
Ideno(1,2,3-cd)pyrene	ug/kg	300	ND	ND	ND
Dibenzo(a,h)anthracene	ug/kg	300	ND	ND	ND
Benzo(g,h,i)perylene	ug/kg	300	ND	ND	ND
Phenol	ug/kg	300	ND	ND	ND
2-Chlorophenol	ug/kg	300	ND	ND	ND
2-Methylphenol	ug/kg	300	ND	ND	ND
4-Methylphenol	ug/kg	300	ND	ND	ND
2-Nitrophenol	ug/kg	300	ND	ND	ND
2,4-Dimethylphenol	ug/kg	300	ND	ND	ND
Benzoic Acid	ug/kg	1500	ND	ND	ND
2,4-Dichlorophenol	ug/kg	300	ND	ND	ND
4-Chloro-3-methylphenol	ug/kg	300	ND	ND	ND
2,4,6-Trichlorophenol	ug/kg	300	ND	ND	ND
2,4,5-Trichlorophenol	ug/kg	300	ND	ND	ND
2,4-Dinitrophenol	ug/kg	1500	ND	ND	ND
4-Nitrophenol	ug/kg	1500	ND	ND	ND

MDL Method Detection Limit
ND Not detected at or above the MDL.

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April 19, 1990
PACE Project
Number: 400329500

Calif.DWR Central

PACE Sample Number:			733060	733070	733080
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
Parameter	Units	MDL	CQ 0172	CQ 0173	CQ 0174
ORGANIC ANALYSIS					
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)					
2-Methyl-4,6-dinitrophenol	ug/kg	1500	ND	ND	ND
Pentachlorophenol	ug/kg	300	ND	ND	ND
alpha-BHC	ug/kg	300	ND	ND	ND
beta-BHC	ug/kg	300	ND	ND	ND
gamma-BHC	ug/kg	300	ND	ND	ND
delta-BHC	ug/kg	300	ND	ND	ND
Heptachlor	ug/kg	300	ND	ND	ND
Aldrin	ug/kg	300	ND	ND	ND
Heptachlor Epoxide	ug/kg	300	ND	ND	ND
Endosulfan I	ug/kg	300	ND	ND	ND
4,4'-DDE	ug/kg	1500	ND	ND	ND
Dieldrin	ug/kg	300	ND	ND	ND
Endrin	ug/kg	300	ND	ND	ND
Endosulfan II	ug/kg	300	ND	ND	ND
4,4'-DDD	ug/kg	300	ND	ND	ND
Endrin Aldehyde	ug/kg	1500	ND	ND	ND
4,4'-DDT	ug/kg	300	ND	ND	ND
Endosulfan Sulfate	ug/kg	1500	ND	ND	ND
Aroclor-1016	ug/kg	3000	ND	ND	ND
Aroclor-1221	ug/kg	3000	ND	ND	ND
Aroclor-1232	ug/kg	3000	ND	ND	ND
Aroclor-1242	ug/kg	3000	ND	ND	ND
Aroclor-1248	ug/kg	3000	ND	ND	ND
Aroclor-1254	ug/kg	3000	ND	ND	ND
Aroclor-1260	ug/kg	3000	ND	ND	ND
Nitrobenzene-d5 (Surrogate Recovery)			49%	68%	144%
2-Fluorobiphenyl (Surrogate Recovery)			64%	82%	169%
Terphenyl-d14 (Surrogate Recovery)			76%	107%	217%
2-Fluorophenol (Surrogate Recovery)			67%	86%	0%(*)

(*) Acid phenolic surrogates were not added to sample
MDL Method Detection Limit
ND Not detected at or above the MDL.

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Parameter	Units	MDL	CQ 0175
PACE Sample Number:			733090
Date Collected:			03/29/90
Date Received:			03/29/90
ORGANIC ANALYSIS			
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)			
Hexachloroethane	ug/kg	300	ND
Nitrobenzene	ug/kg	300	ND
Isophorone	ug/kg	300	ND
Bis(2-chloroethoxy)methane	ug/kg	300	ND
1,2,4-Trichlorobenzene	ug/kg	300	ND
Naphthalene	ug/kg	300	ND
4-Chloroaniline	ug/kg	300	ND
Hexachlorobutadiene	ug/kg	300	ND
2-Methylnaphthalene	ug/kg	300	ND
Hexachlorocyclopentadiene	ug/kg	300	ND
2-Chloronaphthalene	ug/kg	300	ND
2-Nitroaniline	ug/kg	1500	ND
Dimethylphthalate	ug/kg	300	ND
Acenaphthylene	ug/kg	300	ND
2,6-Dinitrotoluene	ug/kg	300	ND
3-Nitroaniline	ug/kg	1500	ND
Acenaphthene	ug/kg	300	ND
Dibenzofuran	ug/kg	300	ND
2,4-Dinitrotoluene	ug/kg	300	ND
Diethylphthalate	ug/kg	300	ND
Fluorene	ug/kg	300	ND
4-Nitroaniline	ug/kg	1500	ND
4-Chlorophenylphenylether	ug/kg	300	ND
N-Nitrosodiphenylamine	ug/kg	300	ND
1,2-Diphenylhydrazine	ug/kg	300	ND
4-Bromophenylphenylether	ug/kg	300	ND
Hexachlorobenzene	ug/kg	300	ND
Phenanthrene	ug/kg	300	ND
Anthracene	ug/kg	300	ND

MDL Method Detection Limit
ND Not detected at or above the MDL.

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Parameter	Units	MDL	CQ 0175
PACE Sample Number:			733090
Date Collected:			03/29/90
Date Received:			03/29/90
ORGANIC ANALYSIS			
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)			
Di-n-butylphthalate	ug/kg	300	ND
Fluoranthene	ug/kg	300	ND
Benzidine	ug/kg	1500	ND
Pyrene	ug/kg	300	ND
Butylbenzylphthalate	ug/kg	300	ND
Benzo(a)anthracene	ug/kg	300	ND
3,3'-Dichlorobenzidine	ug/kg	600	ND
Chrysene	ug/kg	300	ND
Bis(2-ethylhexyl)phthalate	ug/kg	300	ND
Di-n-octylphthalate	ug/kg	300	ND
Benzo(b)fluoranthene	ug/kg	300	ND
Benzo(k)fluoranthene	ug/kg	300	ND
Benzo(a)pyrene	ug/kg	300	ND
Ideno(1,2,3-cd)pyrene	ug/kg	300	ND
Dibenzo(a,h)anthracene	ug/kg	300	ND
Benzo(g,h,i)perylene	ug/kg	300	ND
Phenol	ug/kg	300	ND
2-Chlorophenol	ug/kg	300	ND
2-Methylphenol	ug/kg	300	ND
4-Methylphenol	ug/kg	300	ND
2-Nitrophenol	ug/kg	300	ND
2,4-Dimethylphenol	ug/kg	300	ND
Benzoic Acid	ug/kg	1500	ND
2,4-Dichlorophenol	ug/kg	300	ND
4-Chloro-3-methylphenol	ug/kg	300	ND
2,4,6-Trichlorophenol	ug/kg	300	ND
2,4,5-Trichlorophenol	ug/kg	300	ND
2,4-Dinitrophenol	ug/kg	1500	ND
4-Nitrophenol	ug/kg	1500	ND

MDL Method Detection Limit
ND Not detected at or above the MDL.

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Parameter	Units	MDL	
PACE Sample Number:			733090
Date Collected:			03/29/90
Date Received:			03/29/90
Parameter	Units	MDL	CQ 0175
ORGANIC ANALYSIS			
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)			
2-Methyl-4,6-dinitrophenol	ug/kg	1500	ND
Pentachlorophenol	ug/kg	300	ND
alpha-BHC	ug/kg	300	ND
beta-BHC	ug/kg	300	ND
gamma-BHC	ug/kg	300	ND
delta-BHC	ug/kg	300	ND
Heptachlor	ug/kg	300	ND
Aldrin	ug/kg	300	ND
Heptachlor Epoxide	ug/kg	300	ND
Endosulfan I	ug/kg	300	ND
4,4'-DDE	ug/kg	1500	ND
Dieldrin	ug/kg	300	ND
Endrin	ug/kg	300	ND
Endosulfan II	ug/kg	300	ND
4,4'-DDD	ug/kg	300	ND
Endrin Aldehyde	ug/kg	1500	ND
4,4'-DDT	ug/kg	300	ND
Endosulfan Sulfate	ug/kg	1500	ND
Aroclor-1016	ug/kg	3000	ND
Aroclor-1221	ug/kg	3000	ND
Aroclor-1232	ug/kg	3000	ND
Aroclor-1242	ug/kg	3000	ND
Aroclor-1248	ug/kg	3000	ND
Aroclor-1254	ug/kg	3000	ND
Aroclor-1260	ug/kg	3000	ND
Nitrobenzene-d5 (Surrogate Recovery)			142%
2-Fluorobiphenyl (Surrogate Recovery)			158%
Terphenyl-d14 (Surrogate Recovery)			192%
2-Fluorophenol (Surrogate Recovery)			0%

MDL Method Detection Limit
ND Not detected at or above the MDL.

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PACE Sample Number:			733030	733040	733050
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
Parameter	Units	MDL	CQ 0169	CQ 0170	CQ 0171
ORGANIC ANALYSIS					
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)					
Terphenyl-d14 (Surrogate Recovery)			95%	92%	87%
2-Fluorophenol (Surrogate Recovery)			84%	72%	81%
Phenol-d5 (Surrogate Recovery)			73%	66%	74%
2,4,6-Tribromophenol(Surrogate Recovery)			40%	37%	39%
Date Extracted for GCMS Semi-volatiles			04/07/90	04/07/90	04/07/90
PESTICIDES AND PCB'S BY EPA 8080					
alpha-BHC	ug/kg	1.0	ND	ND	ND
beta-BHC	ug/kg	1.0	ND	ND	ND
gamma-BHC (Lindane)	ug/kg	1.0	ND	ND	ND
delta-BHC	ug/kg	1.0	ND	ND	ND
Heptachlor	ug/kg	1.0	ND	ND	ND
Aldrin	ug/kg	1.0	ND	ND	ND
Heptachlor Epoxide	ug/kg	1.0	ND	ND	ND
Endosulfan I	ug/kg	1.0	ND	ND	ND
4,4-DDE	ug/kg	2.0	ND	ND	ND
Dieldrin	ug/kg	2.0	ND	ND	ND
Endrin	ug/kg	2.0	ND	ND	ND
Endosulfan II	ug/kg	2.0	ND	ND	ND
4,4-DDD	ug/kg	2.0	ND	ND	ND
Endrin Aldehyde	ug/kg	2.0	ND	ND	ND
4,4-DDT	ug/kg	2.0	ND	ND	ND
Endosulfan Sulfate	ug/kg	2.0	ND	ND	ND
Aroclor-1016	ug/kg	70	ND	ND	ND
Aroclor-1221	ug/kg	70	ND	ND	ND
Aroclor-1232	ug/kg	70	ND	ND	ND
Aroclor-1242	ug/kg	70	ND	ND	ND
Aroclor-1248	ug/kg	70	ND	ND	ND
Aroclor-1254	ug/kg	30	ND	ND	ND
Aroclor-1260	ug/kg	30	ND	ND	ND

MDL Method Detection Limit
ND Not detected at or above the MDL.

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Parameter	Units	MDL	CQ 0169	CQ 0170	CQ 0171
PACE Sample Number:			733030	733040	733050
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
ORGANIC ANALYSIS					
PESTICIDES AND PCB'S BY EPA 8080					
Chlordane	ug/kg	20	ND	ND	ND
Toxaphene	ug/kg	30	ND	ND	ND
Methoxychlor	ug/kg	20	ND	ND	ND
2,4,5,6-TCMX (Surrogate Recovery)		1.0	142%	110%	131%
Date Extraction Started			04/07/90	04/06/90	04/07/90
TOTAL PETRO HYDROCARBONS EPA 9071/418.1					
Total Petroleum Hydrocarbons, by IR	mg/kg wet	50	ND	ND	ND
Date Extracted (For LUFT O&G by IR)			04/09/90	04/09/90	04/09/90

MDL Method Detection Limit
ND Not detected at or above the MDL.

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PACE Sample Number:			733060	733070	733080
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
Parameter	Units	MDL	CQ 0172	CQ 0173	CQ 0174
ORGANIC ANALYSIS					
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)					
Phenol-d5 (Surrogate Recovery)			63%	77%	0% (*)
2,4,6-Tribromophenol(Surrogate Recovery)			28%	43%	0% (*)
Date Extracted for GCMS Semi-volatiles			04/07/90	04/07/90	04/07/90
PESTICIDES AND PCB'S BY EPA 8080					
alpha-BHC	ug/kg	1.0	ND	ND	ND
beta-BHC	ug/kg	1.0	ND	ND	ND
gamma-BHC (Lindane)	ug/kg	1.0	ND	ND	ND
delta-BHC	ug/kg	1.0	ND	ND	ND
Heptachlor	ug/kg	1.0	ND	ND	ND
Aldrin	ug/kg	1.0	ND	ND	ND
Heptachlor Epoxide	ug/kg	1.0	ND	ND	ND
Endosulfan I	ug/kg	1.0	ND	ND	ND
4,4-DDE	ug/kg	2.0	ND	ND	ND
Dieldrin	ug/kg	2.0	ND	ND	ND
Endrin	ug/kg	2.0	ND	ND	ND
Endosulfan II	ug/kg	2.0	ND	ND	ND
4,4-DDD	ug/kg	2.0	ND	ND	ND
Endrin Aldehyde	ug/kg	2.0	ND	ND	ND
4,4-DDT	ug/kg	2.0	ND	ND	ND
Endosulfan Sulfate	ug/kg	2.0	ND	ND	ND
Aroclor-1016	ug/kg	70	ND	ND	ND
Aroclor-1221	ug/kg	70	ND	ND	ND
Aroclor-1232	ug/kg	70	ND	ND	ND
Aroclor-1242	ug/kg	70	ND	ND	ND
Aroclor-1248	ug/kg	70	ND	ND	ND
Aroclor-1254	ug/kg	30	ND	ND	ND
Aroclor-1260	ug/kg	30	ND	ND	ND
Chlordane	ug/kg	20	ND	ND	ND
Toxaphene	ug/kg	30	ND	ND	ND

(*) Acid surrogate/phenolics were not added to the sample.
MDL Method Detection Limit
ND Not detected at or above the MDL.

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Parameter	Units	MDL			
PACE Sample Number:			733060	733070	733080
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
			CQ 0172	CQ 0173	CQ 0174
ORGANIC ANALYSIS					
PESTICIDES AND PCB'S BY EPA 8080					
Methoxychlor	ug/kg	20	ND	ND	ND
2,4,5,6-TCMX (Surrogate Recovery)		1.0	121%	114%	124%
Date Extraction Started			04/07/90	04/07/90	04/07/90
TOTAL PETRO HYDROCARBONS EPA 9071/418.1					
Total Petroleum Hydrocarbons, by IR	mg/kg wet	50	ND	ND	ND
Date Extracted (For LUFT O&G by IR)			04/09/90	04/09/90	04/09/90

MDL Method Detection Limit
ND Not detected at or above the MDL.

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Parameter	Units	MDL	
PACE Sample Number:			733090
Date Collected:			03/29/90
Date Received:			03/29/90
Parameter	Units	MDL	CQ 0175
ORGANIC ANALYSIS			
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)			
Phenol-d5 (Surrogate Recovery)			0%
2,4,6-Tribromophenol(Surrogate Recovery)			0%
Date Extracted for GCMS Semi-volatiles			04/07/90
PESTICIDES AND PCB'S BY EPA 8080			
alpha-BHC	ug/kg	1.0	ND
beta-BHC	ug/kg	1.0	ND
gamma-BHC (Lindane)	ug/kg	1.0	ND
delta-BHC	ug/kg	1.0	ND
Heptachlor	ug/kg	1.0	ND
Aldrin	ug/kg	1.0	ND
Heptachlor Epoxide	ug/kg	1.0	ND
Endosulfan I	ug/kg	1.0	ND
4,4-DDE	ug/kg	2.0	ND
Dieldrin	ug/kg	2.0	ND
Endrin	ug/kg	2.0	ND
Endosulfan II	ug/kg	2.0	ND
4,4-DDD	ug/kg	2.0	ND
Endrin Aldehyde	ug/kg	2.0	ND
4,4-DDT	ug/kg	2.0	ND
Endosulfan Sulfate	ug/kg	2.0	ND
Aroclor-1016	ug/kg	70	ND
Aroclor-1221	ug/kg	70	ND
Aroclor-1232	ug/kg	70	ND
Aroclor-1242	ug/kg	70	ND
Aroclor-1248	ug/kg	70	ND
Aroclor-1254	ug/kg	30	ND
Aroclor-1260	ug/kg	30	ND
Chlordane	ug/kg	20	ND
Toxaphene	ug/kg	30	ND

MDL Method Detection Limit
ND Not detected at or above the MDL.

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PACE Sample Number:			733090
Date Collected:			03/29/90
Date Received:			03/29/90
Parameter	Units	MDL	CQ 0175
ORGANIC ANALYSIS			
PESTICIDES AND PCB'S BY EPA 8080			
Methoxychlor	ug/kg	20	ND
2,4,5,6-TCMX (Surrogate Recovery)		1.0	119%
Date Extraction Started			04/07/90
TOTAL PETRO HYDROCARBONS EPA 9071/418.1			
Total Petroleum Hydrocarbons, by IR	mg/kg wet	50	ND
Date Extracted (For LUFT O&G by IR)			04/09/90

MDL Method Detection Limit
ND Not detected at or above the MDL.

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PACE Sample Number:			733100	733110	733120
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
Parameter	Units	MDL	CAM EXT. CQ 0169	CAM EXT. CQ 0170	CAM EXT. CQ 0171
INORGANIC ANALYSIS					
CAM METALS, IN WATER					
Antimony (EPA Method 6010/200.7)	mg/L	0.06	ND	ND	ND
Arsenic (EPA Method 7060, Furnace AAS)	mg/L	0.005	0.038	0.088	ND
Barium (EPA 6010, ICP)	mg/L	0.01	5.1	4.8	1.2
Beryllium (EPA Method 6010/200.7, ICP)	mg/L	0.01	ND	ND	ND
Cadmium (EPA 6010/200.7, ICP)	mg/L	0.005	ND	ND	ND
Chromium (EPA 6010/200.7)	mg/L	0.01	0.36	0.31	0.04
Cobalt (EPA 6010/200.7, ICP)	mg/L	0.01	0.34	0.30	0.09
Copper	mg/L	0.01	0.06	0.02	0.10
Lead	mg/L	0.1	0.2	ND	ND
Mercury (EPA Method 7470, Cold Vapor AA)	mg/L	0.0002	ND	ND	ND
Molybdenum	mg/L	0.02	ND	ND	ND
Nickel	mg/L	0.02	0.59	0.48	0.11
Selenium (EPA Method 7740, Furnace AAS)	mg/L	0.005	ND	ND	ND
Silver (EPA 6010, ICP)	mg/L	0.01	ND	ND	ND
Thallium	mg/L	0.2	ND	ND	ND
Vanadium	mg/L	0.01	0.88	0.81	0.13
Zinc (EPA Method 6010/200.7, ICP-AES)	mg/L	0.01	2.2	2.4	1.5

MDL Method Detection Limit
ND Not detected at or above the MDL.

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Parameter	Units	MDL	733130 03/29/90 03/29/90 CAM EXT. CQ 0172	733140 03/29/90 03/29/90 CAM EXT. CQ 0173	733150 03/29/90 03/29/90 CAM EXT. CQ 0174
PACE Sample Number:			733130	733140	733150
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
INORGANIC ANALYSIS					
CAM METALS, IN WATER					
Antimony (EPA Method 6010/200.7)	mg/L	0.06	ND	ND	ND
Arsenic (EPA Method 7060, Furnace AAS)	mg/L	0.005	0.038	ND	ND
Barium (EPA 6010, ICP)	mg/L	0.01	4.4	4.3	3.9
Beryllium (EPA Method 6010/200.7, ICP)	mg/L	0.01	ND	ND	ND
Cadmium (EPA 6010/200.7, ICP)	mg/L	0.005	ND	ND	ND
Chromium (EPA 6010/200.7)	mg/L	0.01	0.40	0.28	0.28
Cobalt (EPA 6010/200.7, ICP)	mg/L	0.01	0.39	0.40	0.44
Copper	mg/L	0.01	ND	0.03	0.23
Lead	mg/L	0.1	0.1	0.2	0.2
Mercury (EPA Method 7470, Cold Vapor AA)	mg/L	0.0002	ND	ND	ND
Molybdenum	mg/L	0.02	ND	ND	ND
Nickel	mg/L	0.02	0.66	0.67	0.75
Selenium (EPA Method 7740, Furnace AAS)	mg/L	0.005	ND	ND	ND
Silver (EPA 6010, ICP)	mg/L	0.01	ND	ND	ND
Thallium	mg/L	0.2	ND	ND	ND
Vanadium	mg/L	0.01	0.75	0.52	0.52
Zinc (EPA Method 6010/200.7, ICP-AES)	mg/L	0.01	2.7	3.1	2.5

MDL Method Detection Limit
ND Not detected at or above the MDL.

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Parameter	Units	MDL	CAM EXT. CQ 0175
PACE Sample Number:			733160
Date Collected:			03/29/90
Date Received:			03/29/90
INORGANIC ANALYSIS			
CAM METALS, IN WATER			
Antimony (EPA Method 6010/200.7)	mg/L	0.06	ND
Arsenic (EPA Method 7060, Furnace AAS)	mg/L	0.005	0.050
Barium (EPA 6010, ICP)	mg/L	0.01	4.1
Beryllium (EPA Method 6010/200.7, ICP)	mg/L	0.01	ND
Cadmium (EPA 6010/200.7, ICP)	mg/L	0.005	ND
Chromium (EPA 6010/200.7)	mg/L	0.01	0.31
Cobalt (EPA 6010/200.7, ICP)	mg/L	0.01	0.37
Copper	mg/L	0.01	0.23
Lead	mg/L	0.1	0.1
Mercury (EPA Method 7470, Cold Vapor AA)	mg/L	0.0002	ND
Molybdenum	mg/L	0.02	ND
Nickel	mg/L	0.02	0.57
Selenium (EPA Method 7740, Furnace AAS)	mg/L	0.005	ND
Silver (EPA 6010, ICP)	mg/L	0.01	ND
Thallium	mg/L	0.2	ND
Vanadium	mg/L	0.01	0.62
Zinc (EPA Method 6010/200.7, ICP-AES)	mg/L	0.01	2.8

MDL Method Detection Limit
ND Not detected at or above the MDL.

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Department of Water Resources, Central
3251 S. Street
Sacramento, CA 95816

April 19, 1990
PACE Project Number: 400329500

Attn: Mr. Bruce Agee

Calif.DWR Central

PACE Sample Number:			733030	733040	733050
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
Parameter	Units	MDL	CQ 0169	CQ 0170	CQ 0171
INORGANIC ANALYSIS					
CAM METALS, TOTAL CONCENTRATIONS					
Antimony	mg/kg wet	10	ND	ND	ND
Arsenic (EPA 7060, Graphite Furnace AAS)	mg/kg wet	10	ND	ND	ND
Barium (EPA 6010, ICP)	mg/kg wet	1	94	88	34
Beryllium (EPA 6010, ICP)	mg/kg wet	1	ND	ND	ND
Cadmium (EPA 6010, ICP)	mg/kg wet	1	ND	ND	ND
Chromium (EPA 6010)	mg/kg wet	1	31	30	6.5
Cobalt (EPA 6010, ICP)	mg/kg wet	1	8.3	8.7	4.4
Copper (EPA 6010, ICP)	mg/kg wet	1	30	30	5.8
Lead	mg/kg wet	10	ND	ND	ND
Mercury (EPA Method 7471)	mg/kg wet	0.02	0.14	0.46	37
Molybdenum	mg/kg wet	2	ND	ND	ND
Nickel	mg/kg wet	2	32	28	4.9
Selenium	mg/kg wet	10	21	14	ND
Silver (EPA 6010, ICP)	mg/kg wet	1	ND	ND	ND
Thallium	mg/kg wet	20	ND	ND	ND
Vanadium	mg/kg wet	1	30	28	12
Zinc	mg/kg wet	1	70	73	69
ORGANIC ANALYSIS					
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)					
N-Nitrosodimethylamine	ug/kg	300	ND	ND	ND
Aniline	ug/kg	300	ND	ND	ND
Bis(2-chloroethyl) ether	ug/kg	300	ND	ND	ND
1,3-Dichlorobenzene	ug/kg	300	ND	ND	ND
Benzyl Alcohol	ug/kg	300	ND	ND	ND
1,4-Dichlorobenzene	ug/kg	300	ND	ND	ND
1,2-Dichlorobenzene	ug/kg	300	ND	ND	ND

MDL Method Detection Limit
ND Not detected at or above the MDL.

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Calif.DWR Central

PACE Sample Number:			733060	733070	733080
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
Parameter	Units	MDL	CQ 0172	CQ 0173	CQ 0174
INORGANIC ANALYSIS					
CAM METALS, TOTAL CONCENTRATIONS					
Antimony	mg/kg wet	10	ND	ND	ND
Arsenic (EPA 7060, Graphite Furnace AAS)	mg/kg wet	10	ND	ND	ND
Barium (EPA 6010, ICP)	mg/kg wet	1	80	81	92
Beryllium (EPA 6010, ICP)	mg/kg wet	1	ND	ND	ND
Cadmium (EPA 6010, ICP)	mg/kg wet	1	ND	ND	ND
Chromium (EPA 6010)	mg/kg wet	1	37	32	46
Cobalt (EPA 6010, ICP)	mg/kg wet	1	8.8	9.8	11
Copper (EPA 6010, ICP)	mg/kg wet	1	38	31	32
Lead	mg/kg wet	10	ND	ND	ND
Mercury (EPA Method 7471)	mg/kg wet	0.02	7.6	34	30
Molybdenum	mg/kg wet	2	ND	ND	ND
Nickel	mg/kg wet	2	39	38	46
Selenium	mg/kg wet	10	20	18	14
Silver (EPA 6010, ICP)	mg/kg wet	1	ND	ND	ND
Thallium	mg/kg wet	20	ND	ND	ND
Vanadium	mg/kg wet	1	30	28	37
Zinc	mg/kg wet	1	30	92	82
ORGANIC ANALYSIS					
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)					
N-Nitrosodimethylamine	ug/kg	300	ND	ND	ND (*)
Aniline	ug/kg	300	ND	ND	ND
Bis(2-chloroethyl) ether	ug/kg	300	ND	ND	ND
1,3-Dichlorobenzene	ug/kg	300	ND	ND	ND
Benzyl Alcohol	ug/kg	300	ND	ND	ND
1,4-Dichlorobenzene	ug/kg	300	ND	ND	ND
1,2-Dichlorobenzene	ug/kg	300	ND	ND	ND
Bis(2-chloroisopropyl) ether	ug/kg	300	ND	ND	ND
N-Nitrosodipropylamine	ug/kg	300	ND	ND	ND

MDL Method Detection Limit
ND Not detected at or above the MDL.

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PACE Project Number: 400329500

Calif.DWR Central

PACE Sample Number:			733090
Date Collected:			03/29/90
Date Received:			03/29/90
Parameter	Units	MDL	CQ 0175
INORGANIC ANALYSIS			
CAM METALS, TOTAL CONCENTRATIONS			
Antimony	mg/kg wet	10	ND
Arsenic (EPA 7060, Graphite Furnace AAS)	mg/kg wet	10	ND
Barium (EPA 6010, ICP)	mg/kg wet	1	88
Beryllium (EPA 6010, ICP)	mg/kg wet	1	ND
Cadmium (EPA 6010, ICP)	mg/kg wet	1	ND
Chromium (EPA 6010)	mg/kg wet	1	39
Cobalt (EPA 6010, ICP)	mg/kg wet	1	10
Copper (EPA 6010, ICP)	mg/kg wet	1	40
Lead	mg/kg wet	10	ND
Mercury (EPA Method 7471)	mg/kg wet	0.02	0.15
Molybdenum	mg/kg wet	2	ND
Nickel	mg/kg wet	2	40
Selenium	mg/kg wet	10	17
Silver (EPA 6010, ICP)	mg/kg wet	1	ND
Thallium	mg/kg wet	20	ND
Vanadium	mg/kg wet	1	33
Zinc	mg/kg wet	1	84
ORGANIC ANALYSIS			
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)			
N-Nitrosodimethylamine	ug/kg	300	ND (*)
Aniline	ug/kg	300	ND
Bis(2-chloroethyl) ether	ug/kg	300	ND
1,3-Dichlorobenzene	ug/kg	300	ND
Benzyl Alcohol	ug/kg	300	ND
1,4-Dichlorobenzene	ug/kg	300	ND
1,2-Dichlorobenzene	ug/kg	300	ND
Bis(2-chloroisopropyl) ether	ug/kg	300	ND
N-Nitrosodipropylamine	ug/kg	300	ND

MDL Method Detection Limit
ND Not detected at or above the MDL.

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Calif.DWR Central

Parameter	Units	MDL	BATCH METHOD BLANK	BATCH REPLIC. RPD	BATCH MAT.SPIKE RECOVERY
PACE Sample Number:			733170	733180	733190
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
INORGANIC ANALYSIS					
CAM METALS, TOTAL CONCENTRATIONS					
Antimony	mg/kg wet	10	ND	0%	31%
Arsenic (EPA 7060, Graphite Furnace AAS)	mg/kg wet	10	ND	0%	108%
Barium (EPA 6010, ICP)	mg/kg wet	1	ND	3.2%	99%
Beryllium (EPA 6010, ICP)	mg/kg wet	1	ND	0%	98%
Cadmium (EPA 6010, ICP)	mg/kg wet	1	ND	0%	95%
Chromium (EPA 6010)	mg/kg wet	1	ND	0%	102%
Cobalt (EPA 6010, ICP)	mg/kg wet	1	ND	2.4%	92%
Copper (EPA 6010, ICP)	mg/kg wet	1	ND	0%	92%
Lead	mg/kg wet	10	ND	0%	94%
Mercury (EPA Method 7471)	mg/kg wet	0.02	ND	6.4%	121%
Molybdenum	mg/kg wet	2	ND	0%	104%
Nickel	mg/kg wet	2	ND	9.8%	93%
Selenium	mg/kg wet	10	ND	4.9%	82%
Silver (EPA 6010, ICP)	mg/kg wet	1	ND	0%	93%
Thallium	mg/kg wet	20	ND	0%	98%
Vanadium	mg/kg wet	1	ND	2.9%	98%
Zinc	mg/kg wet	1	ND	2.9%	99%
ORGANIC ANALYSIS					
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)					
N-Nitrosodimethylamine	ug/kg	300	ND	-	-
Aniline	ug/kg	300	ND	-	-
Bis(2-chloroethyl) ether	ug/kg	300	ND	-	-
1,3-Dichlorobenzene	ug/kg	300	ND	-	-
Benzyl Alcohol	ug/kg	300	ND	-	-
1,4-Dichlorobenzene	ug/kg	300	ND	0%	79%
1,2-Dichlorobenzene	ug/kg	300	ND	-	-

MDL Method Detection Limit
ND Not detected at or above the MDL.

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Parameter	Units	MDL	BATCH METHOD BLANK	BATCH REPLIC. RPD	BATCH MAT.SPIKE RECOVERY
PACE Sample Number:			733170	733180	733190
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
ORGANIC ANALYSIS					
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)					
Bis(2-chloroisopropyl) ether	ug/kg	300	ND	-	-
N-Nitrosodipropylamine	ug/kg	300	ND	-	-
Hexachloroethane	ug/kg	300	ND	-	-
Nitrobenzene	ug/kg	300	ND	-	-
Isophorone	ug/kg	300	ND	-	-
Bis(2-chloroethoxy)methane	ug/kg	300	ND	-	-
1,2,4-Trichlorobenzene	ug/kg	300	ND	-	-
Naphthalene	ug/kg	300	ND	-	-
4-Chloroaniline	ug/kg	300	ND	-	-
Hexachlorobutadiene	ug/kg	300	ND	-	-
2-Methylnaphthalene	ug/kg	300	ND	-	-
Hexachlorocyclopentadiene	ug/kg	300	ND	-	-
2-Chloronaphthalene	ug/kg	300	ND	-	-
2-Nitroaniline	ug/kg	1500	ND	-	-
Dimethylphthalate	ug/kg	300	ND	-	-
Acenaphthylene	ug/kg	300	ND	-	-
2,6-Dinitrotoluene	ug/kg	300	ND	-	-
3-Nitroaniline	ug/kg	1500	ND	-	-
Acenaphthene	ug/kg	300	ND	6%	74%
Dibenzofuran	ug/kg	300	ND	-	-
2,4-Dinitrotoluene	ug/kg	300	ND	53% (*)	82%
Diethylphthalate	ug/kg	300	ND	-	-
Fluorene	ug/kg	300	ND	-	-
4-Nitroaniline	ug/kg	1500	ND	-	-
4-Chlorophenylphenylether	ug/kg	300	ND	-	-
N-Nitrosodiphenylamine	ug/kg	300	ND	-	-
1,2-Diphenylhydrazine	ug/kg	300	ND	-	-

MDL Method Detection Limit
ND Not detected at or above the MDL.

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PACE Sample Number:			733170	733180	733190
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
Parameter	Units	MDL	BATCH METHOD BLANK	BATCH REPLIC. RPD	BATCH MAT.SPIKE RECOVERY
ORGANIC ANALYSIS					
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)					
4-Bromophenylphenylether	ug/kg	300	ND	-	-
Hexachlorobenzene	ug/kg	300	ND	-	-
Phenanthrene	ug/kg	300	ND	-	-
Anthracene	ug/kg	300	ND	-	-
Di-n-butylphthalate	ug/kg	300	ND	-	-
Fluoranthene	ug/kg	300	ND	-	-
Benzidine	ug/kg	1500	ND	-	-
Pyrene	ug/kg	300	ND	10%	74%
Butylbenzylphthalate	ug/kg	300	ND	-	-
Benzo(a)anthracene	ug/kg	300	ND	-	-
3,3'-Dichlorobenzidine	ug/kg	600	ND	-	-
Chrysene	ug/kg	300	ND	-	-
Bis(2-ethylhexyl)phthalate	ug/kg	300	ND	-	-
Di-n-octylphthalate	ug/kg	300	ND	-	-
Benzo(b)fluoranthene	ug/kg	300	ND	-	-
Benzo(k)fluoranthene	ug/kg	300	ND	-	-
Benzo(a)pyrene	ug/kg	300	ND	-	-
Ideno(1,2,3-cd)pyrene	ug/kg	300	ND	-	-
Dibenzo(a,h)anthracene	ug/kg	300	ND	-	-
Benzo(g,h,i)perylene	ug/kg	300	ND	-	-
Phenol	ug/kg	300	ND	12%	81%
2-Chlorophenol	ug/kg	300	ND	-	-
2-Methylphenol	ug/kg	300	ND	-	-
4-Methylphenol	ug/kg	300	ND	-	-
2-Nitrophenol	ug/kg	300	ND	-	-
2,4-Dimethylphenol	ug/kg	300	ND	-	-
Benzoic Acid	ug/kg	1500	ND	-	-

MDL Method Detection Limit
ND Not detected at or above the MDL.

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Calif.DWR Central

Parameter	Units	MDL	BATCH METHOD BLANK	BATCH REPLIC. RPD	BATCH MAT.SPIKE RECOVERY
PACE Sample Number:			733170	733180	733190
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
ORGANIC ANALYSIS					
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)					
2,4-Dichlorophenol	ug/kg	300	ND	-	-
4-Chloro-3-methylphenol	ug/kg	300	ND	15%	81%
2,4,6-Trichlorophenol	ug/kg	300	ND	-	-
2,4,5-Trichlorophenol	ug/kg	300	ND	-	-
2,4-Dinitrophenol	ug/kg	1500	ND	-	-
4-Nitrophenol	ug/kg	1500	ND	67%	14%
2-Methyl-4,6-dinitrophenol	ug/kg	1500	ND	-	-
Pentachlorophenol	ug/kg	300	ND	15%	56%
alpha-BHC	ug/kg	300	ND	-	-
beta-BHC	ug/kg	300	ND	-	-
gamma-BHC	ug/kg	300	ND	-	-
delta-BHC	ug/kg	300	ND	-	-
Heptachlor	ug/kg	300	ND	-	-
Aldrin	ug/kg	300	ND	-	-
Heptachlor Epoxide	ug/kg	300	ND	-	-
Endosulfan I	ug/kg	300	ND	-	-
4,4'-DDE	ug/kg	1500	ND	-	-
Dieldrin	ug/kg	300	ND	-	-
Endrin	ug/kg	300	ND	-	-
Endosulfan II	ug/kg	300	ND	-	-
4,4'-DDD	ug/kg	300	ND	-	-
Endrin Aldehyde	ug/kg	1500	ND	-	-
4,4'-DDT	ug/kg	300	ND	-	-
Endosulfan Sulfate	ug/kg	1500	ND	-	-
Aroclor-1016	ug/kg	3000	ND	-	-
Aroclor-1221	ug/kg	3000	ND	-	-
Aroclor-1232	ug/kg	3000	ND	-	-

MDL Method Detection Limit
ND Not detected at or above the MDL.

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Parameter	Units	MDL	BATCH METHOD BLANK	BATCH REPLIC. RPD	BATCH MAT.SPIKE RECOVERY
PACE Sample Number:			733170	733180	733190
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
ORGANIC ANALYSIS					
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)					
Aroclor-1242	ug/kg	3000	ND	-	-
Aroclor-1248	ug/kg	3000	ND	-	-
Aroclor-1254	ug/kg	3000	ND	-	-
Aroclor-1260	ug/kg	3000	ND	-	-
Nitrobenzene-d5 (Surrogate Recovery)			84%	7%	77%
2-Fluorobiphenyl (Surrogate Recovery)			84%	12%	72%
Terphenyl-d14 (Surrogate Recovery)			92%	36%	91%
2-Fluorophenol (Surrogate Recovery)			86%	11%	90%
Phenol-d5 (Surrogate Recovery)			86%	10%	81%
2,4,6-Tribromophenol(Surrogate Recovery)			44%	0%	44%
Date Extracted for GCMS Semi-volatiles			04/07/90	-	-
PESTICIDES AND PCB'S BY EPA 8080					
alpha-BHC	ug/kg	1.0	ND	-	-
beta-BHC	ug/kg	1.0	ND	-	-
gamma-BHC (Lindane)	ug/kg	1.0	ND	13.5%(*)	118%
delta-BHC	ug/kg	1.0	ND	-	-
Heptachlor	ug/kg	1.0	ND	12.0%	159%
Aldrin	ug/kg	1.0	ND	24.7%	141%
Heptachlor Epoxide	ug/kg	1.0	ND	-	-
Endosulfan I	ug/kg	1.0	ND	-	-
4,4-DDE	ug/kg	2.0	ND	-	-
Dieldrin	ug/kg	2.0	ND	-	-
Endrin	ug/kg	2.0	ND	33.0%	48%
Endosulfan II	ug/kg	2.0	ND	-	-
4,4-DDD	ug/kg	2.0	ND	-	-
Endrin Aldehyde	ug/kg	2.0	ND	-	-
4,4-DDT	ug/kg	2.0	ND	-	-

MDL Method Detection Limit
ND Not detected at or above the MDL.

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Parameter	Units	MDL	733170	733180	733190
PACE Sample Number:			733170	733180	733190
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
			BATCH METHOD BLANK	BATCH REPLIC. RPD	BATCH MAT.SPIKE RECOVERY
ORGANIC ANALYSIS					
PESTICIDES AND PCB'S BY EPA 8080					
Endosulfan Sulfate	ug/kg	2.0	ND	-	-
Aroclor-1016	ug/kg	70	ND	-	-
Aroclor-1221	ug/kg	70	ND	-	-
Aroclor-1232	ug/kg	70	ND	-	-
Aroclor-1242	ug/kg	70	ND	-	-
Aroclor-1248	ug/kg	70	ND	-	-
Aroclor-1254	ug/kg	30	ND	-	-
Aroclor-1260	ug/kg	30	ND	-	-
Chlordane	ug/kg	20	ND	-	-
Toxaphene	ug/kg	30	ND	-	-
Methoxychlor	ug/kg	20	ND	-	-
2,4,5,6-TCMX (Surrogate Recovery)		1.0	121%	20.4%	110%
Date Extraction Started			04/07/90	-	-
TOTAL PETRO HYDROCARBONS EPA 9071/418.1					
Total Petroleum Hydrocarbons, by IR	mg/kg wet	50	ND	1.3%	115%
Date Extracted (For LUFT O&G by IR)			04/09/90	04/09/90	04/09/90

MDL Method Detection Limit
ND Not detected at or above the MDL.

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April 19, 1990
PACE Project
Number: 400329500

Calif.DWR Central

PACE Sample Number: 733200
Date Collected: 03/29/90
Date Received: 03/29/90

Parameter	Units	MDL	QC BATCH NUMBER
INORGANIC ANALYSIS			
CAM METALS, TOTAL CONCENTRATIONS			
Antimony	mg/kg wet	10	N1500/M816
Arsenic (EPA 7060, Graphite Furnace AAS)	mg/kg wet	10	N2539/M815
Barium (EPA 6010, ICP)	mg/kg wet	1	N1500/M816
Beryllium (EPA 6010, ICP)	mg/kg wet	1	" "
Cadmium (EPA 6010, ICP)	mg/kg wet	1	" "
Chromium (EPA 6010)	mg/kg wet	1	" "
Cobalt (EPA 6010, ICP)	mg/kg wet	1	" "
Copper (EPA 6010, ICP)	mg/kg wet	1	" "
Lead	mg/kg wet	10	" "
Mercury (EPA Method 7471)	mg/kg wet	0.02	N5120/M121
Molybdenum	mg/kg wet	2	N1500/M816
Nickel	mg/kg wet	2	" "
Selenium	mg/kg wet	10	N2538/M815
Silver (EPA 6010, ICP)	mg/kg wet	1	N1500/M816
Thallium	mg/kg wet	20	" "
Vanadium	mg/kg wet	1	" "
Zinc	mg/kg wet	1	" "
ORGANIC ANALYSIS			
EXTRACTABLE ORGANICS BY EPA 8270 (GC/MS)			
N-Nitrosodimethylamine	ug/kg	300	Z2032/P650
Date Extracted for GCMS Semi-volatiles			P818
PESTICIDES AND PCB'S BY EPA 8080			
2,4,5,6-TCMX (Surrogate Recovery)		1.0	E2051/P819
Date Extraction Started			P819
TOTAL PETRO HYDROCARBONS EPA 9071/418.1			
Total Petroleum Hydrocarbons, by IR	mg/kg wet	50	P820/P-IRV
Date Extracted (For LUFT O&G by IR)			P820

MDL Method Detection Limit

11 Digital Drive ☐ Novato, CA 94949 ☐ Phone (415) 883-6100
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REPORT OF LABORATORY ANALYSIS

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Novato, California
Leawood, Kansas
Irvine, California
Asheboro, North Carolina

Mr. Bruce Agee
Page 29

April 19, 1990
PACE Project
Number: 400329500

Calif.DWR Central

Parameter	Units	MDL	CAM BLANK	CAM MATRIX DUPLICATE	CAM MATRIX SPIKE
PACE Sample Number:			735080	735090	735100
Date Collected:			03/29/90	03/29/90	03/29/90
Date Received:			03/29/90	03/29/90	03/29/90
INORGANIC ANALYSIS					
CAM METALS, IN WATER					
Antimony (EPA Method 6010/200.7)	mg/L	0.06	ND	0%	110%
Arsenic (EPA Method 7060, Furnace AAS)	mg/L	0.005	ND	0%	76%
Barium (EPA 6010, ICP)	mg/L	0.01	ND	0%	110%
Beryllium (EPA Method 6010/200.7, ICP)	mg/L	0.01	ND	0%	94%
Cadmium (EPA 6010/200.7, ICP)	mg/L	0.005	ND	0%	100%
Chromium (EPA 6010/200.7)	mg/L	0.01	0.01	0%	98%
Cobalt (EPA 6010/200.7, ICP)	mg/L	0.01	ND	5.7%	96%
Copper	mg/L	0.01	ND	0%	92%
Lead	mg/L	0.1	ND	35%*	90%
Mercury (EPA Method 7470, Cold Vapor AA)	mg/L	0.0002	ND	0%	102%
Molybdenum	mg/L	0.02	ND	0%	113%
Nickel	mg/L	0.02	0.04	1.7%	96%
Selenium (EPA Method 7740, Furnace AAS)	mg/L	0.005	ND	0%	61%
Silver (EPA 6010, ICP)	mg/L	0.01	ND	0%	91%
Thallium	mg/L	0.2	ND	0%	78%
Vanadium	mg/L	0.01	ND	0%	97%
Zinc (EPA Method 6010/200.7, ICP-AES)	mg/L	0.01	0.02	4.6%	100%

MDL Method Detection Limit
ND Not detected at or above the MDL.

The data contained in this report were obtained using EPA or other approved methodologies. All analyses were performed by me or under my supervision.

Stephen Nackord

Stephen F. Nackord
Director, Sampling and Analytical Services

11 Digital Drive ☐ Novato, CA 94949 ☐ Phone (415) 883-6100

STATE OF CALIFORNIA
RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

DIVISION OF DESIGN AND CONSTRUCTION
DESIGN OFFICE
CIVIL DESIGN BRANCH

SOILS AND CONCRETE LABORATORY
REPORT NO. 90-11

SEDIMENT SAMPLING
NORTH DELTA

APRIL 6, 1990

State of California | The Resources Age

Memorandum

Date : April 6, 1990

To : Bruce Agee
Central District

From : Michael W. Driller
Soils & Concrete Laboratory
Department of Water Resources

Subject: Soil Test Request 90-11, Sediment Study, North Delta EIR

Attached are the results of testing performed under Soil Test Request No. 90-11, "Sediment Study - North Delta." Samples were received with the request on March 29, 1990.

Testing consisted of hydrometer and mechanical particle size analysis and organic content tests on seven (7) liter-size plastic jar samples obtained on March 28, 1990.

<u>Organic Content</u>
Organic content was determined by ASTM Test Designation D2974-84, "Moisture, Ash and Organic Matter of Peat Materials." Results are listed on the attached summary sheet.

<u>Hydrometer and Mechanical Particle-Size Analysis</u>
Hydrometer and mechanical particle size analyses were performed according to ASTM Test Designation D 422, "Particle-Size Analysis of Soils." The No. 4 sieve was used to separate material for testing. Results are listed on the attached summary sheet and gradation plot.

Attachments
- Classification Test Summary
- Gradation Plot
- Soil Test Request

cc: Ralph Torres 3-7987
West Sacramento Soils and Concrete Lab

SURNAME	M. DRILLER 4-6-90			
DWR 155 (Rev. 2/86)				

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

DIVISION OF DESIGN AND CONSTRUCTION
DESIGN OFFICE
CIVIL DESIGN BRANCH

CLASSIFICATION TEST SUMMARY

PROJECT Central Distict
FEATURE Sediment Sampling - North Delta

SHEET NO. 1 OF 1

LAB. NO.	LOCATION: HOLE NO.	LOCATION: F.S. NO.	LOCATION: ELEV. OR DEPTH	MECHANICAL ANALYSIS - % FINER: GRAVEL 6"	GRAVEL 3"	GRAVEL 1.5"	GRAVEL 3/4"	GRAVEL 3/8"	SAND 4	SAND 8	SAND 16	SAND 30	SAND 50	SAND 100	SAND 200	SILT & CLAY 5M	SILT & CLAY 2M	SILT & CLAY 1M	ATTERBERG LIMITS L.L.	ATTERBERG LIMITS P.I.	G_s -#4	% ORG	COMMENTS
90-446	CQ-	0169												100	98	54	34	22				9.5	
447	CQ-	0170									100	99	99	99	98	44	27	17				9.7	
448	CQ-	0171									100	88	28	5	3	1	0	0				0.7	
449	CQ-	0172										100	99	97	96	40	27	18				6.7	
450	CQ-	0173				100	92	84	79	77	76	74	71	62	49	24	17	14				4.0	
451	CQ-	0174										100	99	96	89	21	12	8				4.7	
452	CQ-	0175											100	98	97	40	26	18				6.4	

495

DATE April 4, 1990
INITIAL MWD
REQUEST NO. 90-11

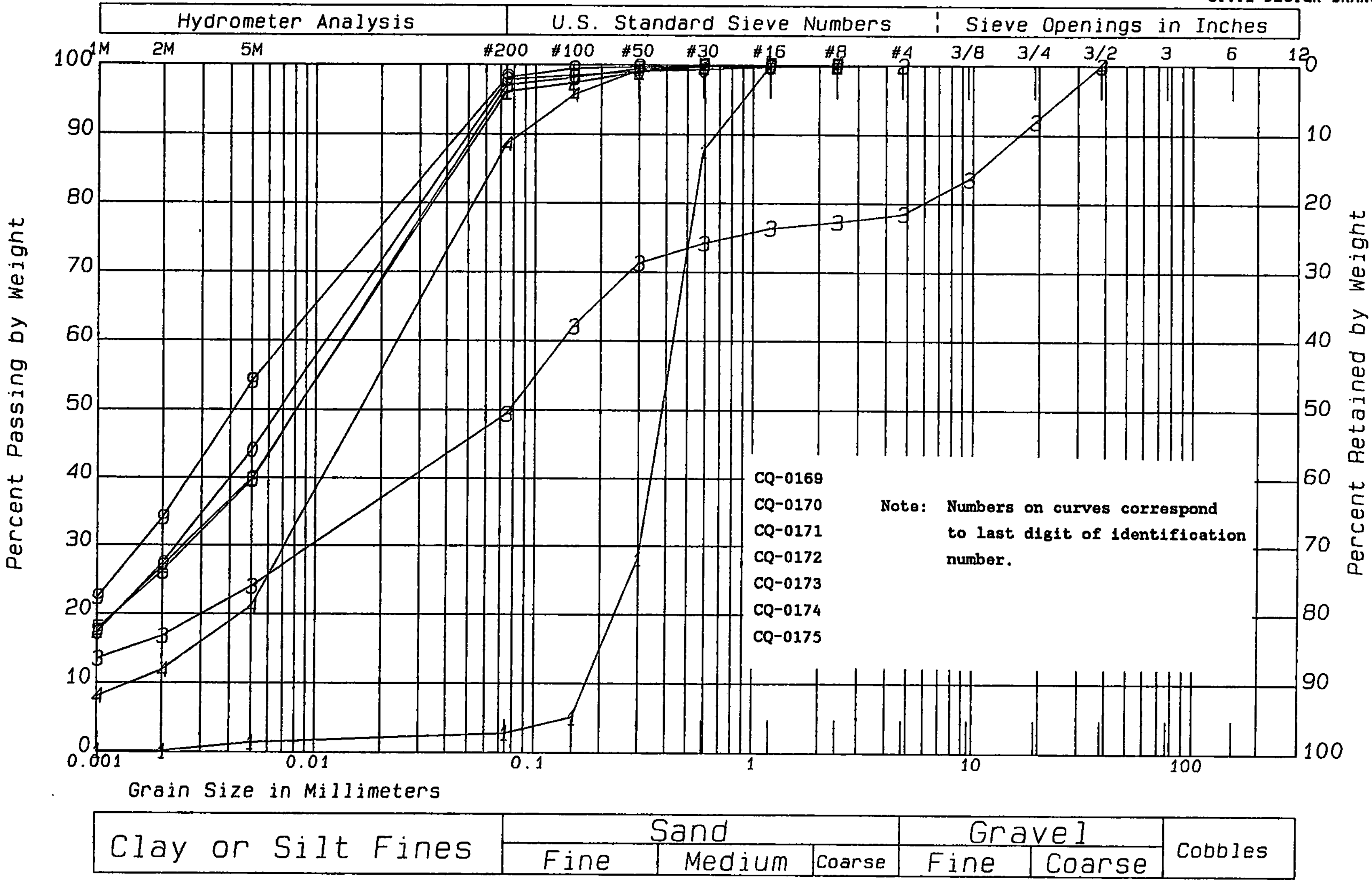
REMARKS

IM - INSUFFICIENT MATERIA
NP - NON-PLASTIC
NG - NO GOOD

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

DIVISION OF DESIGN AND CONSTRUCTION
DESIGN OFFICE
CIVIL DESIGN BRANCH

Mechanical Analysis Graph



SEDIMENT SAMPLING - NORTH DELTA

REQUEST NO. 90-11

(Date Plotted - 4/6/90)

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DIVISION OF DESIGN AND CONSTRUCTION
DESIGN OFFICE
CIVIL DESIGN BRANCH

For Soils Lab Use

Request No. 90-11
Received 3-29-90
Est. Cost $

TEST REQUEST

TO: SOILS AND CONCRETE LABORATORY

Date 3-28-90

FROM:
Division or District Central District

Project Sediment Sampling North Delta

Branch Data Management

Feature E.I.R.

Section Water Quality Unit No. 6304

Work Order No. 1465-3031

Call Lab at 445-9912 for information on Sample Requirements and test procedures and requirements. Attach Form No. 1282 or other sheets for sample identification. Conduct tests in accordance with the following instructions:

Organic Content (ASTM D2974-84)
Mechanical Analysis (ASTM D422)
Hydrometer Analysis (ASTM D422)

CQ-0169*
CQ-0170
CQ-0171
CQ-0172
CQ-0173
CQ-0174
CQ-0175

One liter container per lab number.

*Note CQ-0169 has only 1/2 liter of sample.

Need Test Data By (give specific date; ASAP gets lowest priority) April 4, 1990

Test Samples in Following Sequence

Disposition of Samples

Bruce Agee
Individual Requesting Services

Central District
Mailing Address

3-8897
Telephone No.

DWR 723 (Rev. 7/87)

APPENDIX J
SEISMIC REPORT SUMMARY

APPENDIX J
SEISMIC REPORT SUMMARY

No comprehensive study regarding seismic risk of levees and structures within the North Delta area has been performed so far. However, a preliminary seismic risk analysis of typical levees and structures in the South Delta, was done by Bureau of Reclamation in February, 1989. The goal of that preliminary study was to provide a generalized framework for assessing the seismic risk for typical water management facilities in the South Delta area.

The scope of that study was limited and did not include a comprehensive review of data for any aspect of the study.

The first part of the analysis consisted of a probabilistic assessment which integrated all relevant earthquake sources in the region, and yielded peak horizontal acceleration and velocity values for an exposure period of 10 0 years and a probability of non-exceedance of 0.9. The maximum values computed were 0.18 g and 25.1 cm/sec, respectively. The second part of the analysis consisted of a geotechnical and failure probability analysis for two representative South Delta levees. Liquefaction potential was analyzed with shear strength and SPT data from a neighboring, similar site. Deformation and settlement analyses were also performed.

There have been many prior assessments of the seismic hazard and risk for various portions and facilities within the Delta area. The scope of that preliminary study did not permit a comprehensive review of all previous work on this subject. DWR (1980) reviewed potential seismicity hazards in the Delta region and recommended further studies and investigations. DWR (1982) examined the problems and feasibility of upgrading and rehabilitating the levees in the Delta region. The McDonald Island Levee stability studies by Dames and Moore (1985) found at least a 50 percent chance of levee failure due to liquefaction in the next 50 years for the levees they studied. Newmarch (1985) evaluated the potential for earthquake induced levee failures in the Delta and outlined potential future studies.

Principal sources of earthquakes in the region include the many late quaternary faults of the region such as the San Andreas, Hayward, and Calaveras, as well as the more local sources in the North Delta. Most of the probable seismicity which may affect the North Delta study area seem to be related to faults that are considered part of the San Andreas fault system.

Historical stability problems throughout the Delta indicate the significance of the seismic risk to levees at numerous locations. Poor construction techniques, inadequate design and unfavorable foundation conditions have combined to create constant maintenance problems. The addition of seismic loads to structures of already marginal stability are causes for concern.

All of the north Delta project alternatives include either reinforcing of existing levees or construction of new levees or a combination of both.

A potential cause of levee failure in the Delta that has not been fully studied is liquefaction of the foundation due to earthquake. Liquefaction is a phenomenon whereby, during shaking from an earthquake, saturated sands lose strength and flow like a liquid. Liquefaction potential depends on ground acceleration, material types and relative density. Other factors which can influence liquefaction potential in the Delta include type and size of seismic waves generated, duration and amplitude of ground shaking, drainage conditions, and degree of saturation of levees and foundation materials.

Apart from foundation failure, earthquake shaking also has the potential to cause slope failures.

The big earthquake of October 17, 1989, known as the "Loma Prieta earthquake" with a magnitude of 7.1 on the Richter scale caused no apparent levee failures in the Delta which was approximately 60 miles from the epicenter. The seismograph at Clifton Court Forebay recorded a maximum ground acceleration of 0.08g for that earthquake.

Informations and reports from various sources indicate that there is significant risk of levee failure due to earthquake loads in the Delta. The Corps completed a preliminary report on liquefaction in the Delta titled "Sacramento-San Joaquin Delta Liquefaction Potential" April 1987, which also indicates the existence of failure potentials due to an earthquake.

Earthquake considerations are complex and earthquake loadings will be considered during the project design process.

APPENDIX K
ARCHAEOLOGICAL REPORT SUMMARY

APPENDIX K
ARCHAEOLOGICAL REPORT SUMMARY

To complete the Class I records survey of cultural resources, the North and Central California Information Centers (Sacramento and San Joaquin counties) were contacted for information regarding archaeological, historical and cultural resources in the project area. Confidential reports issued by representatives of these organizations indicate that only one site of significant archaeological, historical, or cultural value is within or located adjacent to the project site. This prehistoric site has been almost destroyed by farming activities (CSUS, 1989).

The reports stressed the need for a comprehensive survey of the project site to determine the full extent of unrecorded archaeological or historical cultural resources.

DWR is contracting with the U.S. Bureau of Reclamation for an intensive Class II prehistoric and historic cultural resources survey and evaluation of areas that may be affected by the North Delta Program. The study is required by federal law and will result in a report which identifies and evaluates cultural resources in the region.

Although the archeological survey and its sites are confidential, certain information regarding the reports mentioned above will be made available to the public on request.

APPENDIX L
RECREATION REPORT SUMMARY

APPENDIX L
RECREATION REPORT SUMMARY

PURPOSE AND SCOPE

The purpose of this recreation plan is to analyze any effects which may be associated with proposed water development modifications. Documents were researched to determine the capacity of current North Delta recreational facilities and to help in the determination of recommendations relating to size and location as well as alternative developments required to meet existing and projected future demand.

RECREATIONAL VISITATION AND USE

The Delta has supported about 12 million recreation days annually since 1977. A 1980 California Department of Water Resources survey indicated that more than 75 percent of the Delta recreationists use the portion of the Delta west of Old River and northwest of the Mokelumne River. The major activities in order of usage include fishing, boating, water-skiing, hunting, and enjoyment of various scenic and photographic opportunities. The North Delta area, which contains roughly one-third of the Delta land, is estimated to receive 35 percent of the total Delta recreational use.

POPULATION

Results of the most recent field surveys, which were conducted in June 1977 through April 1979, indicated that most Delta recreationists lived in five counties within a 50-mile radius. The counties and their representative percentages are:

Contra Costa	29.4
San Joaquin	16.7
Sacramento	16.0
Alameda	10.4
Solano	4.8

Map 1 shows the percentage of recreationists coming from each of the 5 counties of the major market area and the nearly 30 counties within the secondary market area. Population growth is the major contributor to the increased recreational demand. Higher incomes, increased numbers of retirees, and shorter workweeks also contribute to increased demand.

Published reports indicate the 1980 California population was 23.75 million and 28 million in 1987. These reports reflect over an 18 percent increase in the 7-year period. Population estimates and forecasts for the five Delta counties contributing 77 percent of the recreationists projected the following percentage increase between 1980 and 1990

Contra Costa	17.0
San Joaquin	39.0
Sacramento	26.9
Alameda	15.0
Solano	24.0
Average	24.4

ACTIVITIES

As indicated by Table 1, recreationists in the Delta enjoy a wide variety of recreational activities. The table also exhibits the popularity of each of these activities. Motorboating and fishing are the most popular activities with over 47 percent participation each, followed by relaxing, driving for pleasure, and sightseeing which each receive over 30 percent participation.

Table 1 - Recreation Participation in Delta Activities

Activity	Percent Participation By Individuals	Percent Participation By Visitation
Motorboating	47.6	15.2
Fishing	47.5	15.1
Relaxing	38.6	12.2
Driving for Pleasure	36.2	11.5
Sightseeing	33.1	10.5
Overnight Camping	26.2	8.3
Picnicking	22.9	7.3
Swimming	21.1	6.7
Water-skiing	14.7	4.7
Photography	10.1	3.2
Sailing	4.2	1.3
Bicycling	3.6	1.2
Canoe-Kayak-Rowing	2.5	0.8
Dirt Bike	2.5	0.8
Hunting	2.0	0.6
Snorkeling or Scuba	0.9	0.3
Flying		0.3
Total		100.0

PREVIOUS STUDIES

Numerous studies regarding recreation in the Delta have been made since 1976. Several studies, listed in the bibliography, were used as sources of information and, in combination with field trips to the area, enabled development of an understanding of the problems facing the North Delta recreationists.

The primary sources of information were the following documents:

Sacramento-San Joaquin Delta Outdoor Recreation Survey (E. Z. Cajucom & Associates, March 1980)

Draft Environmental Impact Statement-Sacramento/San Joaquin California (Corps of Engineers, 1982)

General Plan for Brannan Island and Franks Tract State Recreation Areas (University of California and EDAW, February 1988)

Delta Map and Guide-The Sacramento & San Joaquin Rivers (Schell's Books, (1989) Interstate 5, the major highway between Sacramento and Stockton, and the east and west California highways 12 and 160 are the major access routes to the North Delta area. Many commercial recreational facilities in the-Delta are clustered near a central location which enables ready access to a majority of the waterways in the Delta. Recreational use of the North Delta, as well as the remaining Delta area, is constrained by a lack of publicly-owned land, public access, and relatively few public facilities.

Competition for space occurs between participants in various recreational activities because of large numbers of participants and a lack of developed recreational areas. The Delta is regulated by many governing bodies, (this includes state, county, city, and local groups) whose goals and policies inherently conflict. These numerous conflicting control policies and guidelines result in an increase in safety and trespass problems. Most of the Delta land area is privately owned with ownership of some levees and islands in question. In many cases, private holdings are not delineated, resulting in unknowing trespass by recreationists.

The water surface acreage available for boating appears to be used by recreationists to a point approaching physical capacity. The heavy use occurs on weekends and especially on holiday weekends. Heavy use reduces the quality of experience and can jeopardize the safety of water recreationists.

Local concerns were expressed about trespass, liability, vandalism, and conflict with wildlife and existing agricultural uses of Delta land if recreation access is increased.

Establishment of a Delta recreation management agency is needed. Such an agency would be able to effectively deal with trespass, liability, vandalism, and user conflicts uniformly throughout the Delta region. Public areas could be identified through the use of signs, colored logos showing designated public areas, color-coded docking and launching facilities, etc. Recreationists could be informed through brochures disseminated by a management agency.

Conflicting recreation uses with wildlife can be reduced through water zoning which would eliminate motorboat encroachment on sensitive areas. A management agency would need to enforce the zoning regulations.

Local concerns expressed support for controlled access for specific recreation uses, compatible with existing uses, such as access for birdwatching on Staten Island.

The concept for diversifying recreation opportunities in the Delta region, including birdwatching, is advocated in both Reclamation recreation studies for North and South Delta. Sensitive areas, such as refuges and wetlands adjacent to and within the Delta area need to be identified and zoned to protect the inherent resource qualities and reduce conflicts with other uses. Recreation use is a potential conflict, especially with the intrusion of motorized vehicles and boats. A Delta recreation management agency could identify zones and enforce protective regulations for sensitive wildlife areas. The key for controlled access lies with establishing a Delta recreation management authority which could address uniform recreation planning, development, operation, maintenance, and law enforcement for the region.

SUPPLY

Facilities operated by a public agency (i.e., state, county, city, etc.) are considered as public for this report. Commercial facilities are those operated for profit by private entities or individuals. Amenities usually found at both public and private (commercial) operations include: boat launching ramps, restrooms, parking for vehicles and vehicles with boat trailers, campsites, and picnic sites.

Public facilities currently in place are heavily used and do not meet the demand. Several public developments are in the planning stage and others have been proposed in the North Delta; however, regulatory approval, funding, and operation and maintenance dilemmas have caused delays in the proposed construction.

There are eight public facilities in the North Delta. Brannan Island State Recreation Area is the largest with 225 acres, 6 launch ramps, and over 250 camp and picnic sites. Records reflect capacity crowds during the major recreation season (mid-May through mid-September) with numerous individuals being turned away. The remaining public areas are of limited size and provide fewer facilities. Sacramento County operates 3 day-use areas, ranging from 1 to 11 acres in size. Hogback Island (11 acres) is the largest with 2 launch ramps, a guest dock, 13 picnic sites, 4 chemical toilets, 55 paved parking spaces for vehicles, and 47 paved parking spaces for vehicles with boat trailers.

Yolo County operates a 4-acre day use area near Clarksburg and Solano County operates a 10-acre facility for camping and picnicking in Rio Vista (the launch ramp for this area was lost in the 1986 flood). The City of Rio Vista operates a 3-acre area with a launch ramp, guest dock, restrooms and a 25-vehicle paved parking area. Table 2 reflects the facilities available at the public areas.

Table 2 – North Delta Public Facilities

Name	Facilities						
	Size (acres)	Launch Ramps	Guest Docks	Camp Sites	Picnic Sites	Rest-rooms	Parking
Brannan Island State Rec. Area Dept. of Parks & Recreation	225	6	X	126	130	X	576 P & U
Clarksburg Fishing Access Yolo County – Day Use Area	4	1				4C	U
Cliff House Fishing Access Sacramento Co. – Day Use Area	2	0				2C	28 P
Georgiana Slough Sacramento Co. – Day Use Area	1	0				2C	P
Hogback Island Sacramento Co. – Day Use Area	11	2	X		13	4C	55P–V 47P–VT
Rio Vista Public Launch Ramp City of Rio Vista	3	1	X			X	25–P
Rio Vista Sandy Beach Park Solano County	10	*		42RV	10	X	150–P
Westgate Landing Park (5 A.dev) San Joaquin County	20	0	X	14RV	15	X	55–P
TOTALS	276	10		182	143		936

KEY: C = Chemical RV = Recreational Vehicle
P = Paved VT = Vehicle and Trailer
U = Unpaved * = Lost in 1986 Flood

There were numerous discrepancies between reference documents regarding commercial facilities available in the Delta. The amount of land and the facilities available are not clearly defined. Parking is the limiting factor for access to the North Delta waterways and was used as the basis for accessibility to water-related recreational activities for this recreation plan. Fifteen percent was added to the reported commercial parking spaces available to ensure against unreported parking and calculations are based on the higher figure.

Parking at commercial and public facilities in the North Delta, according to available information, consists of 6,894 spaces for vehicles alone and 199 spaces for vehicles with boat trailers. Applying a multiple of 4 persons per vehicle and 3 persons per vehicle with boat trailer, the existing parking will accommodate 27,576 + 597 or 28,173 people per day. Addition of a 15 percent increment to account for parking areas where the size is not indicated or facilities were recently constructed results in an estimated capacity of 32,399 people. Parking which occurs outside regularly designated parking areas has not been included in this report.

The North Delta has a total of 47 commercial facilities which consist of marinas, boat harbors, resorts, recreational vehicle parks, and several sites of interest. These commercial establishments range from 2 having only guest docks to 1 having 396 campsites, 6 launch lanes, nearly 200 berths, a 500-vehicle capacity paved parking area, rental houseboats and fishing boats, and boat and engine repair facilities. It is assumed that the information concerning existing facilities is complete. Tables 3 and 4 reflect the services available at each commercial facility.

The recreation demand for the North Delta is assumed to be 35 percent of the Delta demand and is separated from the total Delta demand for purposes of this study. The demand section explores the resident and non-resident general recreation demands and interprets the application of the demand studies.

Table 3 – North Delta Boat Rental & Services

RESORTS AND HARBORS	RENTALS			SERVICE			
	House Boats	Fishing Boats	Launch Lanes	Boat Repair	Dry Docks	Boat Lift	Pump Out
B & W Resort			3				
Boathouse, The	X			X		X	X
Bruno's Is. Y.H.							X
Collinsville Resort		X	1				
Courtland Docks	X		1				
Deckhand Supply		X		X			
Delta Country HBoat	X	X	1				
Delta Marina Y.H.			1	X	X	X	X
Eddo's Harbor		X	1	E			
Island Marina			1				
Kanes Marina		X					
Ko-Ket Resort			1				
Korth's Pirate Lair		X	1				
Lighthouse Resort			1	X			X
Moore's Riverboat				X	X		
Munyer's Is. Marine				X	X		
New Hope Landing	X	X	1				X
Ox Bow Marina			1	E			X
Perry's Boat Harbor					X	X	X
Rancho Marina					X	X	X
Rio Vista Sandy Bch			2				
Snug Harbor			1				
Steamboaters	X			E			
Tower Park Marina	X	X		X	X	X	X
Vieira's Resort		X	2	X			
Walnut Grove Marine	(Same as Delta Country Houseboats)						
Wimpy's Marina			2				

KEY: E = Engine repair only

Table 4 - North Delta Commercial Facilities Availability

RESORTS AND HARBORS	Camp Sites	Picnic° Sites	Elec	Water	Rest-room	Guest Docks	Berths Covered	Berths Open	Parking Space Paved	Parking Space Unpaved
Andreas Cove					X			24		38
B & W Resort					X	X	70	36		4 A
Boathouse, The					C				150	
Bruno's Island Y.H.		4 C			C					9 A
Cliff House					X	X	5	5		25
Collinsville Resort	30				X	X	2	5		X
Courtland Docks					X	X		30		32
Cruiser Haven					X	X	300			3 A
Deckhand Supply					X	X				
Delta Marina Y.H.	25	2 C	X	X	X	X	200	50		275
Duck Island R. V. Park	51									
Eddo's Harbor	X	15			X	X				100
Ernie's						X				30
Giusti's					X	X			40	20
Golden Gate Resort	40T	12			X	X	3			
Grand Island Inn					X	X				
Grand Is. Mansion					X					
Happy Harbor					X	X	8	20	50	
Herman & Helen's	15CAF	2			X	X	175	2		50
Holiday Flotels								41		X
Ice Chest, The					X	X				
Island Marina	50				X	X				
Kanes Marina						X				
King Is. Resort		12			X	X	185	20		50 V
Ko-Ket Resort	15	16	X	X	X	X				20
Korth's Pirate Lair					X	X			200	
Lighthouse Resort	157	X	X	X	X	X	35	20	50	100
Moore's Riverboat					X	X	50	115	100	
Munyer's Is. Marina					X	X	50		50	
New Hope Landing	30		X	X	X	X		60		20
Outrigger Marina	25				X	X	76		50	
Ox Bow Marina					X	X	425		525	
Paradise Pt. Marina					X	X	85	105		320
Perry's Boat Harbor					X	X	122		500	
Rancho Marina	50	25	X	X	X	X	14	12		2 A
Snug Harbor	65	8	X	X		X	65	35		100
Spindrift Marina					X	X	109	39	60	60
Spot, The	18	6	X	X	X	X			30	
Steamboaters	10				X	X				25
Steamboat Landing						X				
Tower Park Marina	396	X	X	X	X	X	178		500	
Vieira's Resort	24	X	X	X	X	X	146			24
Uncle Bobbie's							36	70		100
Walnut Grove Marine	(Delta	Country	Houseboats)		X	X	69	96	180	1 A
Walnut Gr. Merch Dk.						X				
Walnut Berm Harbor		10					198		200	
Wimpy's Marina	12	4	X	X	X	X		60	X	
TOTALS	958	128					2606	845	2485	1589

KEY: A = Acre; C = Customer use only; CAF = Camp-A-Float; T = Tent; V = Vehicle; VT = Vehicle & Boat Trailer

RESIDENT AND NONRESIDENT DEMAND

The 1980 census data reflected a population of about 200,000 people in the five-county Delta area. Current demand figures indicate that in 1990 each resident of the Delta will spend an average of 53 days recreating on the land and water within its boundaries. Boat registrations in 1980 indicated an ownership of 82,000 boats by the Delta residents. This amounted to 1 boat for each 2.44 people in the 5-county area which produced over 77 percent of the recreational demand within the 50-mile radius (map 1). The 1987 boat registration figures reflect the increasing popularity of boating in the Delta Region. Delta boat registrations in 1987 reflect 107,000 registered boats and a population figure of about 250,000 for a ratio of 1 boat for each 2.34 people (only motorized vessels require registration). Past studies reflect that California State Planners used a ratio of 1 boat for each 30 people during the 1960's.

The 1980 census figures were used for the North Delta Study. Map 1 reflects about 22 percent of the Delta recreation use comes from the counties within a 50- to 100-mile radius. Of these figures, the number using the North Delta facilities cannot be determined.

GENERAL DEMAND

Latent demand is the extent to which existing and future recreation demand exceeds actual use and capacity of existing facilities. In their 1982 study, the Corps of Engineers (Corps) identified the estimated latent demand in the Delta as follows:

Visitor and/or Recreational Day Demand
(Million Recreational Days)

Year	Estimated Demand	Latent Demand
1980	12.3	9.4
1985	12.9	12.6
1990	13.6	15.2
2000	14.1	25.7

These statistics were utilized by Ebasco in their 1988 "Recreation Facilities Plan for North and South Delta" study. The Corps' figures, used for this recreation plan, and the 1990 figures are comparable to 1989 which makes further refinement unnecessary.

The availability of suitable recreation resources and public access are the limiting factors of North Delta recreation. It is therefore unnecessary to project recreation demand to the year 2000. This recreation plan focuses on the estimated 1990 figures for discussions related to planning. The ecological consortium matrix and leisure profile are used to depict the nature of existing demand and its occurrence. The consortium matrix is used to analyze the compatibility of the various activities occurring in the North Delta and produces a basis for management decisions and recommendations.

NORTH DELTA DEMAND

The estimated California population as of January 1988, reported by the Employment Development Department in the July 1988 report, was 28,019,000. The January 1, 1988, figure represents an 18.4 percent increase over the 1980 census figure and indicates that the Corps' 1982 estimated Delta area population for 1990 may be low.

North Delta recreation demand figures were not determined in previous studies. The latent recreational demand in the Delta reflected in the Corp's 1982 study was estimated at 9.4 million recreation days in 1980, 12.6 million in 1985, and 15.2 million in 1990. This study also projected that the facilities which currently exist would handle 14.1 million recreation days in the year 2000. It is assumed that this projection would hold true for 1990; therefore, the 14.1 million days existing demand figure is used for the North Delta study as follows:

	Million Days
Latent Demand	15.2
Actual Demand	14.1
Total Recreation Demand	29.3

These figures indicate that nearly 52 percent of the Delta area demand is unsatisfied and supports Ebasco's conclusion that "The demand for recreation in the Delta far exceeds the capacity of existing facilities." The heaviest use typically occurs on a summer Sunday and application of the design load formula to the estimated 1990 demand figures indicates 109,375 people use the North Delta on a Sunday during the 14-week recreation season.

The average person participates in 2.5 different recreational activities each recreation day which indicates that the North Delta would generate 273,437 activity days on a typical Sunday during the 14-week heavy use recreation season. Table 5 displays activities, percentage of use, demand, units, and acreage requirements to satisfy the 1990 North Delta demand. Parking standards reflect an average of 70 percent of the recreation users arrive in vehicles without trailers while the remaining 30 percent are in vehicles towing boat trailers.

Table 5 – North Delta Recreation Activity Demand

Activity	Percent Participation 1/	Number of Poeple 2/	Number of Units 2/	Number of Acres 2/
Camping	26	28,437	9,479	1,184
Picnicking	23	25,156	6,289	629
Parking				
Vehicles only		75,563	18,890	130
Vehicles with boat trailers		32,812	10,937	410
Acres required to meet the total North Delta Demand				2,353

1/ From Table 1 – rounded to the nearest percent

2/ Figures based on the following accepted standards:
Camping – 3 people per unit and 8 units per acre
Picnicking – 4 people per unit and 10 units per acre
Parking – 300 sq ft and 4 people per vehicle with boat trailer
1,633 sq ft and 3 people per vehicle with boat trailer

PROPOSED DEVELOPMENT

Fishing Access

Fishing access areas would be procured at Georgiana, Hog, and Lost Sloughs and would contain 3 acres each. Two picnic sites, a chemical toilet equipped for the handicapped, and parking space for six vehicles would be provided at each site. In addition to the picnic and parking area, additional land may be necessary through lease or purchase to provide access to each area. Boating traffic should be controlled by zoning in the vicinity of these sites.

Wildlife/Wetland Areas

Snodgrass Slough - Access to Snodgrass Slough would be by boat. An interpretation center, restrooms, or adequate chemical toilets equipped for the handicapped, a viewing center and possibly foot or canoe trails to enable closer viewing of the area should be provided. Foot trails, constructed from dredged material, could be connected with the Southern Pacific railroad right-of-way to provide an access by users of the area recently procured by the State of California. Waterways in the vicinity of these facilities, including Delta Meadows, should be zoned to restrict boating activity.

Staten Island - The acres recommended for wildlife/wetland development on the southern end of Staten Island could range from 20 to 120 acres in size. The 60 acres was used as a mid-range figure. A lease arrangement may be made in which the area to be flooded when waterfowl are present could be used for agricultural purposes during the remainder of the year. Access would be limited. Dredged material may be used to develop the flooded area.

Delta Meadows - The Delta Meadows area, recently procured by the California Department of Parks and Recreation, will continue to provide a scenic area representative of historical wetlands. To complement the Meadows area, the administration of the 46-acre parcel of land bordering the Delta Cross Channel and owned by Reclamation should be turned over to the State Department of Parks and Recreation for use as a natural area under a written agreement. This would enable the state to control access to the area and ease the problems of trespass and litter which now occur regularly.

Channel and Cutoff Islands

The proposed dredging of the South Mokelumne River will provide material which could be used to construct channel islands for use as staging areas for a variety of recreational activities. In some cases, these islands could be provided with picnic and restroom facilities. Dredging also could create cutoff islands to serve as wildlife or natural areas or as destination islands. Setback levees could produce increased flows and provide additional water and shore areas to the benefit of fish and wildlife as well as the public. Some cutoff islands, formed during dredging, could be quite large and useful in providing additional wildlife sanctuaries or public use areas.

SUPPLY-DEMAND ANALYSIS

The limiting factor for access to the North Delta for recreational purposes is availability of vehicle parking space. Existing commercial facilities reported availability of 2,485 paved and 1,589 unpaved parking spaces. A total of 5 marinas reported an additional 19 acres of parking which would accommodate 2,083 vehicle parking spaces. Existing public areas provide a total of 936 parking spaces. Public and commercial parking now is adequate to serve 28,173 people. Addition of 15 percent for unreported parking makes a total of 32,399 people or 30 percent of the existing demand now served. Parking related to facilities proposed for the North Delta area is designed to separate and diversify activities. All parking discussion in this recreation plan is associated only with outdoor recreational pursuits.

ANALYSIS

In 1988, the Ebasco report estimated a 14.1 million recreation day demand by the year 2000 in the Delta area. Given the 28 million plus population estimate for 1987, that demand will have reached the 14.1 million figure by 1990. An estimated 35 percent of the Delta demand, or 4.9 million recreation days, occurs in the North Delta. It is also estimated that 75 percent of the demand (3.7 million recreation days) occurs during the 14-week summer recreational period.

Based on the extensive use of the existing facilities and application of the design load formula and using a 1.2 turnover rate, the total demand on a summer Sunday in the North Delta is 109,375 recreation days. The current facilities accommodate a total of 32,399 recreation days resulting in an unmet demand of 76,976 recreation days during the summer season.

The calculations used to determine the above figures contain an elastic factor in which recreation facilities would be used at 50 percent capacity during weekdays. There would be additional recreational days fulfilled if more nonworking people could be enticed to recreate on weekdays and the off-season period from September 15 through May 15.

The population of the United States continues to increase as does that of the State of California. As a result of longer life expectancy, early retirement, larger income, and workweek reductions, people will increasingly use their leisure time to recreate in popular areas such as the Delta. Inducements to recreate during low-use periods, such as reduction of fees, could eliminate some of the need for increased numbers of facilities.

RECOMMENDATIONS

After consultation with various Delta area agencies, field observations, review of existing guidelines and standards, and a literature review, the following recommendations are presented:

1. If future recreation studies are conducted, a resource inventory should be performed to determine the type and numbers of existing recreational facilities. This information would prove beneficial in determining the utilization and perhaps in limiting or shifting recreational use in certain areas of the North Delta.

2. A public agency representing the counties should be established to assume recreation management responsibilities regarding planning, development, operation, maintenance, and law enforcement for the North Delta or possibly the entire Delta area. The entire Delta area should be managed as one recreation system.

3. The parcels of Bureau of Reclamation land adjacent to the Delta Cross Channel should be turned over to the Department of Parks and Recreation, under written agreement, for their administration together with their other landholdings in the area.

4. The quality of experience and diversity of recreational opportunity should take precedence over the quantity of people served.

5. That zoning be used in heavy use recreation areas designed for activities, for diversity of recreation activities, quality of experience, and protection of fragile wildlife resources.

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APPENDIX M
NARROWING OF ALTERNATIVES

APPENDIX M
NARROWING OF ALTERNATIVES

Proposals for Delta water facilities were made as early as 1890 when early Californians proposed a salt water barrier. During water resources planning studies of the 1920s and 1930s, it became apparent that transfers of water from north of the Delta to south of the Delta would be needed to meet the growing water demands. In 1961, the Interagency Delta Committee (IDC) compared various Delta proposals and classified the plans into four basic concepts: 1) Hydraulic Barriers; 2) Physical Barriers; 3) Waterway Control Plans; and 4) a Peripheral Canal (isolated channel). After public hearings, the IDC recommended the Peripheral Canal in 1965.

1974 Draft Environmental Impact Report, Peripheral Canal Project, August 1974

This draft EIR had objectives of providing transfer capabilities to both the SWP and CVP, improved water quality, improved flow patterns, improved fishery and wildlife habitat, and opportunities for recreation.

The studies looked at six major alternatives and evaluated 34 parameters,including water quality, water levels, and fishery. These parameters were evaluated on a scale from A (best) to D (least). This information was summarized in Table VIII-3 of the 1974 Draft EIR and included in this Appendix as Table M-1.

Reappraisal of Water Management

Under the direction of a new Governor and Department Director, DWR began a reappraisal of the management of the project, including the water supply, and in particular, the need for and types of Delta facilities.

1976–77 Drought

The 1976–77 drought emphasized the need for reevaluations of water supplies, water demands, additional facilities, and improved water management.

1978 Bulletin 76, *Delta Water Facilities*, July 1978

This bulletin was the result of the new State administration policy and the desire to review past planning work. This comprehensive program incorporates several other elements that are essential for the successful resolution of the Delta controversy and for future water management in California. These include:

- serious water conservation efforts;
- the use of water recycling and reclaimed waste water to stretch existing water supplies;
- conjunctive use of the California Aqueduct and presently dewatered ground water storage capacity south of the Delta to bank water during wet years for withdrawal during dry years;
- the development of new water storage reservoirs using the off-stream concept which avoids damming free-flowing rivers;
- construction of the Peripheral Canal and related facilities in the Delta and Suisun Marsh; and most important,
- the necessary environmental and Delta guarantees, which have been lacking in past efforts.

Appendix B of Bulletin 76 included a comprehensive reevaluation of alternatives and components. The alternatives were divided into five categories: 1) actions to reduce Delta export (nine); 2) institutional,legal, and physical measures to provide Delta protection (fifteen); 3) construction of Delta transfer facilities (thirty); 4) provisions for additional facilities south of the Delta (thirteen); and 5) development of additional supplies north of the Delta (twenty-three). Tables from Appendix B of Bulletin 76, follow in this appendix as Tables M-2 through M-9. The tables are titled:

M-2 Alternative Components

M-3 Summary of Alternatives and Plan Components Eliminated or Deferred During Initial Screening

M-4 Plan Components to be Rated

M-5 Plan Components Evaluation Criteria

M-6 Summary of Alternative Component Rating

M-7 Planning Precepts

M-8 Components Comprising the Alternative Plans

M-9 Summary of Composite Plan Rating

1978 State Senate Bill 346

SB 200, which incorporated DWR's program, failed to pass the State Legislature.

1982 State Senate Bill 200

SB 200, which included much from SB 346, contained both statewide water management facilities and specific Delta facilities.

1982 Proposition 9

The June 1982 Proposition 9 referendum measure included Senate Bill 200 but was overturned by the California voters after an emotional campaign against the Peripheral Canal.

1982 Urban Water Management Planning Act of 1983

This act required more than 300 of the urban water suppliers to prepare water management plans that identify the water conservation programs they have implemented and proposed for the future.

1983 DWR Report, *Alternatives for Delta Water Transfer,* Released in November 1983

This report discusses physical alternatives to the Peripheral Canal for transferring water across the Sacramento-San Joaquin Delta. Four basic alternatives, which were considered the most promising, have been selected from a large number of alternatives. All four are variations of "through-Delta" plans, in which water is conveyed through existing channels of the central Delta.

1986 Agricultural Water Management Planning Act of 1986

This act requires all major agricultural water retailers to report to DWR on how they manage their water. The suppliers must also adopt an agricultural water management plan that identifies their water conservation programs.

1987 Scoping Meeting

The South Delta Water Management Program and North Delta Water Management Program held public scoping meetings to obtain local and statewide input.

1988 Planning Reports

The objectives of each program were defined in the planning reports for the North, South, and West Delta Water Management Programs.

1990 Draft EIR/EIS proposed to be released.

> **NOTE:** The following tables, M-1 through M-10, have been reproduced from the 1974 Draft EIR on the Peripheral Canal and from Bulletin 76, *Delta Water Facilities*, dated July 1978. The tables are presented to help readers understand past methods and the criteria used during the narrowing process.

Table M–1
Comparison of Delta Alternatives with the Proposed Action

IMPACT RANKING
ACCEPTABLE IMPACT
A- BEST
B-
C-
D - LEAST

E- ACCEPTABILITY QUESTIONABLE
F- UNACCEPTABLE IMPACT
U- RELATIVE NET EFFECT UNKNOWN

Impact Parameters	Peripheral Canal	State-only Gravity Canal	Waterway Control	Modified Folsom-South	Physical Barrier	Hyd. Barrier No Project
Export Water Supply	B	B	B	E	A	D
Export water Quality	A	B	A	B	C	D
Local water Quality	C	C	B	B	A	C
Water Level	A	B	B	B	C	B
Seepage	B	A	A	A	A	A
Delta Flood Control	A	A	A	B	A	B
Channol Scour (Delta)	A	B	A	B	A	C
Navigation (Delta)	A	A	D	B	C	A
Transportation (Delta)	C	C	A	B	C	C
Land Out of Production (Delta)	C	C	B	B	A	A
Recreation	A	B	C	C	C	C
Fish						
General Factors						
1. Salinity Gradient and	A	B	C	C	E	B
Dissolved Oxygen	A	C	B	C	E	D
2. Food Supply						
Striped Bass						
1. Sacramento River	A	B	B	D	C	C
2. San Joaquin R iver	A	C	A	B	C	D
3. Nursery Area	A	C	B	C	F	D
Sacramento Salmon						
1. Upstream Migrants	B	A	B	E	C	A
2. Downstream Migrants	A	A	A	B	E	C
San Joaquin Salmon						
1. Upstream Migrants	A	D	B	C	F	E
2. Downstream Migrants	A	C	A	C	E	D
Mokelumne Salmon	A	C	C	C	E	D
Shad	U	U	U	U	D	U
Sturgeon	U	U	U	U	U	U
Resident Game Fish						
1. Dead-end Sloughs	A	B	C	C	D	C
2. Main Delta Channe1s	A	C	B	B	C	C
Non-Game Fish	A	C	C	B	E	C
Suisun Marsh Fish	A	A	A	A	A	A
Bay Fish	A	A	A	A	A	A
Wildlife						
Delta	A	A	B	C	C	C
Suisun Marsh	C	C	C	C	A	B
Turbidity	B	B	B	A	D	B
Water Temperature	B	A	B	A	C	A
Bay Circulation and Dispersion	B	B	B	B	C	A
Energy Requirement	B	A	A	C	A	A

NOTE: This is Table VIII-3 of Draft EIR, Peripheral Canal Project, August 1974

Table M-2
Alternative Components

1. *Reduction of Delta Export*
   - *Water Conservation
   - *Waste Water Reclamation
   - *Reduce Export During Dry Years and Critical Fish Periods
   - Desalting Sea Water
   - Desalting Geothermal Brines
   - Amend Water Service Contracts
   - Curtail Water to New Lands
   - Reduced Central Arizona Project
   - Icebergs

2. *Delta Protection*
   - Institutional and Legal Measures
     - *Environmental Monitoring
     - *Four-Agency Fish and Wildlife Agreement
     - *Limits on Delta Diversions
     - *SWP-CVP Operation Agreement
     - *Federal Participation in Delta Protection
     - *Review and Revision of Delta Water Quality Standards
     - *Delta Water Agency Contracts
   - Physical Measures
     - *Western Delta Overland Water Facilities
     - *South Delta Water Quality Improvement Facilities
     - *Relocation of Contra Costa Canal Intake
     - *Suisun Marsh Facilities
     - Delta-Woodbridge Canal
     - Fish Screens on In-Delta Diversions
     - Fish Hatcheries
     - Improved Delta Levee Maintenance

3. *Delta Water Transfer Alternatives*
   - Existing Channel Conveyance
     - Continue Present Method ("No Project" Alternative)
     - Enlarge Clifton Court Forebay
     - Union Island Forebay
     - Enlarge South Delta Channels
     - Enlarge North Delta Channels
   - Modified Channel Conveyance
     - Waterway Control Plan
     - Cross Delta Transfer Plan
     - Central Delta Plan
     - Combination Waterway Control Plan and Central Delta Plan
     - North Stub Canal
     - South Stub Canal
     - Mathena Landing Cross Channel and South Stub Canal
     - New Hope Cross Channel and Enlarged Clifton Court Forebay
     - New Hope Cross Channel and South Delta Intake Channel
     - Isleton Cross Channel and Enlarged Clifton Court Forebay
     - Isleton Cross Channel and South Stub Canal
   - Isolated Channel Conveyance
     - *Peripheral Canal
     - East Delta Canal
     - East Central Delta Canal
     - Central Delta Canal
     - West Delta Canal
     - Montezuma Hills Reservoir and Canal
     - Isleton Cross Channel Alignment
     - Mathena Landing Isolated Canal
   - Modified and Isolated Channel Conveyance
     - Modified Folsom-South Canal
     - Western Delta Diversion
   - Physical Barriers
     - Chipps Island Barrier
     - Dillon Point Barrier
     - Point San Pablo Barrier
     - Submerged Barrier in Carquinez Strait

4. *Facilities South of the Delta*
   - Off-stream Surface Storage
     - *Los Vaqueros Reservoir
     - Los Banos Grandes Reservoir (alternate)
     - Los Banos Grandes—Los Vaqueros Combination Reservoirs
     - Sunflower Reservoir
   - Ground Water Storage
     - *South San Francisco Bay Basin
     - San Joaquin Valley Basins
       - *Kern River Fan
       - *White Wolf Basin
     - Southern California Basins
       - *San Fernando Valley Ground Water Basin
       - *Chino Ground Water Basin
       - *Southern Mojave River Valley Ground Water Basin (alternate)
       - *Raymond Ground Water Basin (alternate)
       - *Santa Ana Ground Water Basin (alternate)
   - *Mid-Valley Canal

5. *Additional Supply North of the Delta*
   - Revise Operation of SWP and CVP Reservoirs
   - Weather Modification
   - Long-range Weather Forecasting
   - Purchase Dry Year Supplies
   - Purchase Interim Water Supplies from CVP
   - Sacramento Valley Tributary Storage
     - *Cottonwood Creek Project
     - Millville Reservoir
     - Wing Reservoir
     - Schoenfield Reservoir
     - Gallatin Reservoir
     - Newville Reservoir
     - Rancheria Reservoir
     - Marysville Reservoir
     - Nashville Reservoir
   - Sacramento Valley Off-stream Storage
     - Tuscan Buttes Reservoir
     - *Glenn Reservoir—River Diversion
     - *Colusa Reservoir—River Diversion (alternate)
     - Enlarged Lake Berryessa
   - Sacramento Valley Mainstream Storage
     - Enlarged Shasta Reservoir
   - Sacramento Valley Ground Water
     - Stony Creek Fan Basin
     - Thermalito Basin
   - Importation from North Coast Rivers
     - Dos Rios Reservoir
     - English Ridge Reservoir

*Included in Selected Plan as discussed in Chapter V.

Table M-3
Summary of Alternatives and Plan Components Eliminated or Deferred During Initial Screening

NAME OF ALTERNATIVE OR PLAN COMPONENT	BASIS FOR DECISION										
	ADVERSE IMPACT						OTHER REASONS				
	Economics	Energy	Water Supply	Fish, Wildlife, and/or Recreation	Water Quality	Other Environmental Concerns	Technology	Legal, Institutional, and Political	Better Similar Proposal	Part of Another Proposal	Other
REDUCTION OF DELTA EXPORT											
Desalting Sea Water	●	●				●					
Desalting geothermal brines	●					●	●				
Amend water service contracts								●			
Curtail water to new lands											●
Reduced Central Arizona Project								●			
Icebergs		●					●				
DELTA PROTECTION											
Fish hatcheries							●				
DELTA WATER TRANSFER ALTERNATIVES											
Existing channel conveyance											
Union Island Forebay									●		
Enlarge South Delta channels										●	
Enlarge North Delta channels										●	
Modified channel conveyance											
Cross Delta Transfer Plan									●		
Isolated channel conveyance											
Central Delta Canal									●		
Montezuma Hills Resv & Canal (Resv only)	●								●		
Modified and isolated channel conveyance											
Modified Folsom-South Canal		●	●	●							
Western Delta Diversion			●	●							
Physical barriers											
Chipps Island Barrier				●	●						
Dillon Point Barrier				●	●						
Point San Pablo Barrier				●	●						
Submerged Barrier, Carquinez Strait											●
FACILITIES SOUTH OF THE DELTA											
Sunflower Reservoir	●								●		
Raymond Ground Water Basin									●		
ADDITIONAL SUPPLY NORTH OF THE DELTA											
Revise operation of SWP and CVP reservoirs		●		●							
Weather modification							●				
Long-range weather forecasting							●				
Purchase dry year supplies											●
Purchase interim water supplies from CVP										●	
Sacramento Valley tributary storage											
Millville Reservoir									●		
Wing Reservoir									●		
Schoenfield Reservoir									●		
Gallatin Reservoir									●		
Newville Reservoir									●		
Rancheria Reservoir									●		
Nashville Reservoir			●						●		
Sacramento Valley offstream storage											
Tuscan Buttes Reservoir									●		
Enlarged Lake Berryessa						●		●	●		
Importation from north coast rivers											
English Ridge Reservoir								●	●		

Table M-4
Plan Components to be Rated

NORTH OF DELTA COMPONENTS	**DELTA COMPONENTS (Continued)**
Surface Reservoirs	Combination Waterway Control-Central Delta Plan
Cottonwood Creek Project	West Delta Canal
Glenn Reservoir – River Diversion	Montezuma Hills Canal
Enlarged Shasta Reservoir	**SOUTH OF DELTA COMPONENTS**
Dos Rios Reservoir	**Offstream Surface Storage**
Marysville Reservoir	Los Vaqueros Reservoir – Los Banos Grandes Comb.
Ground Water Basins	Los Vaqueros Reservoir
Stony Creek Fan	Los Banos Grandes Reservoir
Thermalito	**Southern California Groundwater Basins**
DELTA COMPONENTS	San Fernando Valley
Peripheral Canal	Chino
East Delta Canal	Southern Mojave
East Central Delta Canal	**San Joaquin Valley Groundwater Basins**
Isleton Cross Channel	Kern River Fan
South Stub Canal	White Wolf
North Stub Canal	**South San Francisco Bay Groundwater Basin**
Mathena Landing Cross Channel – South Stub Canal	**WATER MANAGEMENT COMPONENTS**
Mathena Landing Isolated Canal	**Waste water Reclamation**
Enlarged Clifton Court Forebay	South Bay Area
Isleton Cross Channel – South Stub Canal	Central Coastal Area
Isleton Cross Channel – Enlarged Forebay	Southern California
Waterway Control Plan	**Water Conservation**
Central Delta Plan	

Table M-5
Plan Component Evaluation Criteria

CATEGORY: SYSTEM EFFECTIVENESS (75%)
DEFINITION: The degree to which the proposal is implementable, flexible with time, and reliable.

SUBCATEGORY: IMPLEMENTABILITY (100%)
DEFINITION: The degree to which the proposal can be implemented, considering public acceptance, institutional constraints and financial implications.

CRITERION: PUBLIC ACCEPTANCE (100%)
DEFINITION: The degree to which the proposal is acceptable to those with permit power, elected officials, water users, DWR, USBR, DFG, citizen and environmental groups.

SUBCRITERION: PUBLIC ENTITIES (100%)
DEFINITION: The degree to which the proposal is acceptable to those Public Agencies with permit power, water users, DWR, USBR, DFG, and elected officials, legislative and executive, of various jurisdictions.

SUBCRITERION: CITIZENRY AND ENVIRONMENTAL GROUPS (100%)
DEFINITION: The degree to which the proposal is acceptable to environmental groups and the citizen at large.

CRITERION: FINANCIAL IMPLEMENTABILITY (100%)
DEFINITION: The degree to which the financial requirements of the proposal vary from those of the initially proposed alternative.

The ease with which the financial requirements of the proposal can be met.

CRITERION: LEGAL-INSTITUTIONAL (100%)
DEFINITION: The degree to which the proposal is possible within the constraints of existing federal and state law, authorization, contracts and agreements.

SUBCATEGORY: FLEXIBILITY WITH TIME (70%)
DEFINITION: The degree to which the proposal can respond to change in technology, new standards and changing needs.

CRITERION: NEW TECHNOLOGY (100%)
DEFINITION: The degree to which the proposal or its individual components can incorporate expected advances in technology.

CRITERION: NEW STANDARDS (97%)
DEFINITION: The degree to which the proposed project can respond to foreseeable new environmental quality standards (water quality, air quality, conservation, etc.).

CRITERION: CHANGING NEEDS (100%)
DEFINITION: The degree to which the proposed project can respond to changing population, industrial, and agricultural distribution.

SUBCATEGORY: RELIABILITY (90%)
DEFINITION: The degree to which the proposal can operate reliably, when considering its vulnerability to natural disasters or sabotage and capability to mitigate failures.

CATEGORY: ADEQUACY OF SUPPLY (75%)
DEFINITION: The degree to which the proposal will satisfy the quantity and quality requirements of the Delta and the Service Area.

SUBCATEGORY: DELTA (100%)
DEFINITION: The degree to which the proposal will satisfy the quantity and quality requirements of the Delta.

CRITERION: WATER QUALITY (100%)
DEFINITION: The degree to which the proposal will satisfy water quality requirements in the Delta.

CRITERION: WATER QUANTITY (100%)
DEFINITION: The degree to which the proposal satisfies Delta Water quantities requirements (water levels).

SUBCATEGORY: SERVICE AREAS (97%)
DEFINITION: The degree to which the proposal will satisfy both water quality and quantity requirements in the Service Area.

CRITERION: WATER QUALITY (100%)
DEFINITION: The degree to which the proposal will satisfy water quality requirements in the Service Area.

CATEGORY: ADEQUACY OF SUPPLY (75%) (continued)

CRITERION: WATER QUANTITY (100%)
DEFINITION: The degree to which the proposal will satisfy the water quantity requirements in the Service Area.

CATEGORY: PHYSICAL ENVIRONMENT (100%)
DEFINITION: The degree to which the proposed project affects the physical environment including biota and landforms.

SUBCATEGORY: BIOTA (100%)
DEFINITION: The degree to which the proposal affects the biota of the physical environment, including terrestrial and aquatic ecosystems, and areas of special biological significance.

CRITERION: TERRESTRIAL ECOSYSTEMS (100%)
DEFINITION: The degree to which the proposal affects terrestrial ecosystems, including flora and fauna, with respect to species diversity, productivity, habitats, populations and trophic levels.

CRITERION: AQUATIC ECOSYSTEMS (100%)
DEFINITION: The degree to which the proposal affects aquatic ecosystems, including flora and fauna, with respect to species diversity, productivity, habitats, populations, and trophic levels.

CRITERION: SUISUN MARCH ECOLOGY (100%)
DEFINITION: The degree to which the proposal provides water of sufficient quality to maintain fish and wildlife resources of the marsh.

SUBCATEGORY: LANDFORM ALTERATION (50%)
DEFINITION: The degree to which the proposal would result in changes in the topography of immediate and adjacent areas.

CRITERION: DRAINAGE AND FLOODING (100%)
DEFINITION: The degree to which the proposal modifies existing drainage patterns (including flooding and siltation) in the affected areas.

CRITERION: STABILITY AND EROSION (100%)
DEFINITION: The degree to which the proposal changes landforms which affect stability and erosion of existing lands and features.

CATEGORY: SOCIO-CULTURAL FACTORS (55%)
DEFINITION: The degree to which the proposal affects the human environment.

SUBCATEGORY: LAND USE AND DEMOGRAPHY (100%)
DEFINITION: The degree to which the proposal affects land use, population patterns, and social inter-relationships in the affected areas.

CRITERION: COMPATIBILITY WITH PLANNED USE (100%)
DEFINITION: The degree to which the proposal is compatible with planned land use in the local area as specified in the General Plan, in its absence by current zoning patterns, or in their absence, by existing land use.

CRITERION: COMPATIBILITY WITH RELATED PLANS (100%)
DEFINITION: The degree to which the proposal is compatible with plans of federal, state and local agencies (other than land use), e.g. water basin studies, regional air quality plans, transportation, energy conservation, etc.

CRITERION: DEMOGRAPHY (100%)
DEFINITION: The degree to which the proposal affects population patterns in the affected areas in terms of project-caused population displacement and relocation.

SUBCATEGORY: AMENITIES (15%)
DEFINITION: The degree to which the proposal affects facilities of cultural and recreational value.

CRITERION: ARCHAEOLOGICAL, PALEONTOLOGICAL AND HISTORICAL SITES (100%)
DEFINITION: The degree to which the proposal affects local sites of archaeological, or paleontological, and historical interest.

CATEGORY: SOCIO-CULTURAL FACTORS (55%) (continued)

CRITERION: RECREATIONAL ACTIVITIES (100%)
DEFINITION: The degree to which the proposal affects the availability and quality of recreational opportunities, i.e. hunting, fishing and boating, etc.

SUBCATEGORY: AESTHETICS (55%)
DEFINITION: The degree to which the appearance of the proposal tends to disrupt or enhance the aesthetic impression of the landscape (including waterways).

CATEGORY: ECONOMIC FACTORS (30%)
DEFINITION: The degree to which the proposal causes economic changes in the affected area, in terms of public revenue and costs, employment and business effects, including agriculture and the cost burden imposed by the project.

SUBCATEGORY: PUBLIC FISCAL EFFECTS (55%)
DEFINITION: The degree to which the operation of the completed proposal causes changes in public revenues and costs, by virtue of changes in tax revenues and municipal service costs.

SUBCATEGORY: EMPLOYMENT AND BUSINESS EFFECTS (90%)
DEFINITION: The degree to which the operation of the completed proposal creates or removes job and business revenues in the affected areas.

SUBCATEGORY: AVERAGE ANNUAL EQUIVALENT COST (100%)
DEFINITION: The degree to which the financing and operation of the proposal will be a cost to the water user, as reflected by an amount equal to the annual payment necessary to amortize facilities' capital costs over 50 years at 6%, plus estimated annual O&M cost of the facilities.

CATEGORY: CONSTRUCTION FACTORS (10%)
DEFINITION: The degree to which construction activities affect local economy and transportation networks.

SUBCATEGORY: TRANSPORTATION (60%)
DEFINITION: The degree to which the construction activities associated with the proposal affect ground and water-borne traffic.

SUBCATEGORY: ECONOMIC EFFECTS (100%)
DEFINITION: The degree to which the construction activities affect the level of employment, business, and net public revenues.

CRITERION: PUBLIC FISCAL EFFECTS (100%)
DEFINITION: The degree to which the direct and indirect costs to local government are offset by construction-generated revenues.

CRITERION: EMPLOYMENT AND BUSINESS (100%)
DEFINITION: The degree to which the construction of the facility affects the level of employment and business in the local area.

SUBCATEGORY: LOCAL PUBLIC SERVICE SYSTEMS (80%)

DEFINITION: The degree to which the proposal, during construction, will increase or decrease the actual burden of providing municipal services, in terms of man-power needs, consumption of excess capacities, equipment needs, etc.

CATEGORY: RESOURCE SUPPLY AND DEMAND (60%)
DEFINITION: The degree to which the proposal affects the availability of energy, water, forest, agricultural, or mineral resources in an affected area.

SUBCATEGORY: NET ENERGY USE (100%)
DEFINITION: The degree to which the proposal is a net user or net producer of energy.

SUBCATEGORY: MATERIALS (50%)
DEFINITION: The degree to which the proposal affects present availability and possible future scarcity of resources (land, construction materials).

NOTE: NUMBERS IN PARENTHESIS (100%) ARE WEIGHTING FACTORS.

Table M-6. Summary of Alternative Component Ratings

RATED ITEMS	NORTH OF DELTA							DELTA																SOUTH OF DELTA									WATER MGMT			
						SACTO VALLEY GROUND WATER BASINS																		OFFSTREAM SURFACE STORAGE			GROUND WATER BASINS						WASTE WATER RECLAMATION			
																											SO. CALIFORNIA			S. J. VALLEY						
	Cottonwood Creek	Glenn Reservoir	Enlarged Shasta	Dos Rios Reservoir	Marysville Reservoir	Stony Creek	Thermalito	Peripheral Canal	East Delta Canal	East Cent. Delta Canal	Isleton Cross Channel	South Stub	North Stub	Mathena Land-So. Stub	Mathena Isol. Canal	Enlarged Clifton Court	Isleton Cross Channel - So. Stub	Isleton Cross Channel - Enlarged Forebay	Waterway Control Plan	Central Delta Plan	Comb. Waterway Cont. Central Delta	West Delta Canal	Montezuma Hills Canal	Los Vaqueros - Los Banos Comb.	Los Vaqueros Res.	Los Banos Res.	San Fernando Valley	Chino	Southern Mojave	Kern River	White Wolf	So. San Francisco Bay Ground Water	South Bay	Central Coastal	Southern California	Water Conservation
SYSTEM EFFECTIVENESS	20.1	-3.7	-16.6	-34.3	8.6	35.9	33.9	24.3	10.2	-3.4	-13.9	-10.0	-.4	-13.2	9.4	2.4	-18.6	-18.2	-25.4	-24.7	-26.6	-31.6	-18.6	1.9	-8.4	-5.8	41.3	38.1	33.2	35.5	34.9	22.3	5.4	5.4	5.4	23.7
IMPLEMENTABILITY	30.0	-18.3	-39.2	-49.2	11.7	14.2	14.2	-10.0	-17.5	-23.3	-28.3	-10.8	-13.3	-15.0	-37.5	14.2	-10.8	-3.3	-34.2	-34.2	-37.5	-31.7	-35.8	-17.5	4.2	10.8	33.3	25.0	12.5	18.3	16.7	20.0	28.3	28.3	28.3	26.7
PUBLIC ACCEPTANCE	50.0	30.0	-7.5	-62.5	25.0	17.5	17.5	0	-2.5	-20.0	-20.0	-7.5	-5.0	5.0	-2.5	-2.5	2.5	0	-47.5	-47.5	-47.5	-30.0	-32.5	37.5	37.5	47.5	55.0	55.0	37.5	30.0	50.0	50.0	0	0	0	25.0
PUBLIC ENTITIES	50	35	0	-50	35	35	35	40	35	10	10	15	20	25	35	10	20	15	-20	-20	-20	-10	-15	45	45	45	60	60	25	10	50	50	0	0	0	25
CITIZEN AND ENV. GROUPS	50	25	-15	-75	15	0	0	-40	-40	-50	-50	-30	-30	-15	-40	-15	-15	-15	-75	-75	-75	-50	-50	30	30	50	50	50	50	50	50	50	0	0	0	25
FINANCIAL IMPLEMENTABILITY	15	-60	-85	-45	-20	75	75	0	0	0	-15	-25	15	5	-20	35	15	40	-5	0	-10	-15	-25	-80	-15	-5	65	55	35	60	35	35	35	35	35	75
LEGAL - INSTITUTIONAL	25	-25	-25	-40	30	-50	-50	-30	-50	-50	-50	-50	-50	-55	-55	10	-50	-50	-50	-55	-55	-50	-50	-10	-10	-10	-20	-35	-35	-35	-35	-25	50	50	50	-20
FLEXIBILITY WITH TIME	-.3	-.3	-69.9	-69.9	-16.8	48.8	41.3	21.0	17.7	7.9	14.4	-28.1	-8.3	-14.9	17.7	-17.9	-14.9	-11.4	-13.2	-13.2	-13.2	-33.4	-43.5	-.3	-50.0	-50.0	41.3	41.3	41.3	41.3	41.3	41.3	-33.2	-33.2	-33.2	49.8
NEW TECHNOLOGY	-50	-50	-50	-50	-50	-25	-25	-35	-35	-35	-35	-35	-35	-35	-35	-35	-35	-35	-35	-35	-35	-50	-50	-50	-50	-50	-25	-25	-25	-25	-25	-25	0	0	0	0
NEW STANDARDS	25	25	-80	-80	0	75	75	90	80	50	70	-50	-10	-30	80	-60	-30	-40	-25	-25	-25	-30	-30	5	-50	-50	75	75	75	75	75	75	-50	-50	-50	75
CHANGING NEEDS	25	25	-80	-80	0	75	75	10	10	10	10	0	20	20	10	40	20	40	20	20	20	20	-50	25	-50	-50	75	75	75	75	75	75	-50	-50	-50	75
RELIABILITY	25	10	50	10	25	50	50	65	35	10	-20	5	20	-10	55	5	-30	-45	-25	-23	-25	-30	20	25	10	10	50	50	50	50	50	10	10	10	10	0
ADEQUACY OF SUPPLY	2.4	7.2	7.2	13.5	2.4	3.7	3.7	52.1	49.6	49.6	47.1	12.4	10.9	32.2	49.6	8.7	32.2	25.9	54.8	47.1	50.9	38.2	38.2	6.0	1.2	4.9	-.1	3.6	1.1	-.1	-.1	-2.5	0	-12.3	1.2	14.8
DELTA	-2.5	-10.0	-10.0	-2.5	-2.5	-2.5	-2.5	27.5	22.5	22.5	20.0	7.5	-12.5	10.0	22.5	2.5	10.0	5.0	40.0	20.0	30.0	2.5	2.5	-7.5	-5.0	-5.0	-5.0	-5.0	-7.5	-5.0	-5.0	-5.0	0	0	0	0
WATER QUALITY	0	-5	-5	10	0	0	0	5	5	5	0	-5	-10	-15	5	0	-15	0	15	-10	-5	-25	-25	-15	-10	-10	-10	-10	-15	-10	-10	-10	0	0	0	0
WATER QUANTITY	-5	-15	-15	-15	-5	-5	-5	50	40	40	40	20	-15	35	40	5	35	10	65	50	65	30	30	0	0	0	0	0	0	0	0	0	0	0	0	0
SERVICE AREA	7.5	25.0	25.0	30.0	7.5	10.0	10.0	77.5	77.5	77.5	75.0	17.5	35.0	55.0	77.5	15.0	55.0	47.5	70.0	75.0	72.5	75.0	75.0	20.0	7.5	15.0	5.0	12.5	10.0	5.0	5.0	0	0	-25.0	2.5	30.0
WATER QUALITY	0	0	0	10	0	0	0	100	100	100	95	0	25	55	100	-5	55	40	85	95	90	95	95	0	0	0	0	0	0	0	0	0	-50	-50	-50	0
WATER QUANTITY	15	50	50	50	15	20	20	55	55	55	55	35	45	55	55	35	55	55	55	55	55	55	55	40	15	30	10	25	20	10	10	0	50	0	55	60
PHYSICAL ENVIRONMENT	-17.2	-.9	-13.1	-37.1	.8	-6.6	-5.2	19.1	12.1	9.4	7.1	-3.7	-7.2	-7.4	9.0	-24.1	-9.4	-27.3	-33.2	-28.9	-30.0	-4.3	-4.0	-10.9	-4.2	-7.3	6.4	-11.1	-11.1	-4.9	-11.1	-15.1	25.8	10.5	0	.8
BIOTA	-38.3	-4.3	-3.3	-49.3	-15.0	-7.3	-5.3	12.3	10.7	11.7	10.7	-19.3	-10.8	-13.7	11.0	-32.3	-16.7	-24.7	-22.3	-18.3	-20.0	6.0	1.0	-17.7	-6.3	-11.0	6.7	-16.7	-16.7	-7.3	-16.7	-22.7	38.7	15.8	0	0
TERRESTRIAL ECOSYSTEMS	-50	-33	-37	-70	-33	-3	-7	17	10	13	17	7	13	7	13	-17	0	-13	-27	-13	-20	13	10	-53	-13	-40	0	0	0	13	0	-20	47	47	0	0
AQUATIC ECOSYSTEMS	-63	10	20	-93	-10	-17	-7	45	47	47	40	-47	-27	-30	45	-6.2	-32	-43	-15	-17	-15	30	18	27	7	20	0	0	0	0	0	-13	77	27	0	0
SUISUN MARSH ECOLOGY	-2	10	7	15	-2	-2	-2	-25	-25	-25	-25	-18	-18	-18	-25	-18	-18	-18	-25	-25	-25	-25	-25	-27	-13	-13	20	-50	-50	-35	-50	-35	47	0	0	0
LAND FORM ALTERATION	25.0	2.5	-32.5	-12.5	32.5	-5.0	-5.0	32.5	15.0	5.0	0	27.5	0	5.0	5.0	-7.5	5.0	-32.5	-55.0	-50.0	-50.0	-25.0	10.0	2.5	0	0	0	0	0	0	0	0	0	0	0	2.5
DRAINAGE AND FLOODING	75	40	-15	50	70	0	0	25	10	10	10	15	0	10	10	-10	20	-10	-80	-65	-65	0	0	10	5	5	0	0	0	0	0	0	0	0	0	0
STABILITY AND EROSION	-25	-35	-50	-75	-5	-10	-10	40	20	0	-10	40	0	0	0	-5	-10	-55	-30	-35	-35	-50	20	-5	-5	-5	0	0	0	0	0	0	0	0	0	5
RESOURCE SUPPLY AND DEMAND	1.7	3.3	33.3	-3.3	16.7	-3.3	-6.7	-8.7	-8.7	-8.7	-9.7	-.7	-1.3	-1.3	-9.7	-.7	-1.3	-1.3	-9.0	-8.7	-9.3	-9.7	-43.3	-38.3	-15.0	-13.3	0	-5.0	-6.7	-6.7	-6.7	-6.7	0	0	0	26.7
NET ENERGY USE	5	10	60	0	30	-5	-10	-10	-10	-10	-10	0	0	0	-10	0	0	L	-10	-10	-10	-10	-60	-45	-10	-15	0	-5	-10	-10	-10	-10	0	0	0	40
MATERIALS	-5	-10	-20	-10	-10	0	0	-6	-6	-6	-9	-2	-4	-4	-9	-2	-4	-4	-7	-6	-8	-9	-10	-25	-25	-10	0	-5	0	0	0	0	0	0	0	0
SOCIO-CULTURAL FACTORS	10.3	2.9	-16.5	-32.1	9.6	3.7	3.9	2.9	-7.2	-16.9	-11.0	-6.4	1.5	-14.6	-3.6	-7.8	-9.4	-11.7	-35.9	-26.5	-31.8	-24.1	-14.1	14.7	13.8	17.5	4.1	4.1	4.1	4.1	4.1	4.1	.4	10.2	10.2	0
LAND USE AND DEMOGRAPHY	-10.0	-25.0	-50.0	-75.0	-10.0	6.7	6.7	15.0	13.3	-1.7	-1.7	-3.3	11.7	-3.3	13.3	-11.7	-3.3	-13.3	1.7	0	-1.7	-5.0	-6.7	-3.3	-3.3	-3.3	6.7	6.7	6.7	6.7	6.7	6.7	0	0	0	0
COMPATIBILITY W/PLANNED LAND USE	-10	-25	-50	-75	-10	10	10	-25	-25	-20	-20	-10	-10	-15	-25	-40	-15	-50	10	5	0	-5	-20	0	0	0	10	10	10	10	10	10	0	0	0	0
COMPATIBILITY W/ REL. PLANS	-10	-25	-50	-75	-10	10	10	75	70	20	20	5	50	10	70	10	10	15	0	0	0	5	5	0	0	0	10	10	10	10	10	10	0	0	0	0
DEMOGRAPHY	-10	-25	-50	-75	-10	0	0	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-10	-10	-10	0	0	0	0	0	0	0	0	0	0
AMENITIES	0	-20.0	0	-10.0	-7.5	-2.5	0	25.0	12.5	-15.0	15.0	5.0	12.5	12.5	17.5	-10.0	7.5	-7.5	-25.0	-25.0	-37.5	-20.0	-5.0	5.0	-5.0	0	2.5	2.5	2.5	2.5	2.5	2.5	5.0	5.0	5.0	0
ARCH., PALEO. AND HIST. SITES	-40	-70	-50	-80	-75	0	0	0	0	0	0	0	0	0	0	-25	0	-25	0	0	0	0	0	-50	-50	-50	0	0	0	0	0	0	0	0	0	0
RECREATION ACTIVITIES	40	30	50	60	60	-5	0	50	25	-30	30	10	25	25	35	5	15	10	-50	-50	-75	-40	-10	60	40	50	5	5	5	5	5	5	10	10	10	0
AESTHETICS	50	60	40	40	50	0	0	-25	-50	-45	-35	-15	-20	-30	-40	0	-25	-10	-75	-75	-85	-60	-30	50	50	60	0	0	0	0	0	0	0	30	30	0
ECONOMIC FACTORS	8.0	3.0	-14.7	9.6	8.9	22.0	22.0	8.1	8.5	13.9	5.5	12.3	11.1	9.7	4.9	14.4	10.9	11.1	5.5	3.6	6.9	5.8	2.1	-5.1	7.4	3.2	9.2	11.3	10.2	10.2	10.2	10.2	1.5	4.0	4.0	20.4
PUBLIC FISCAL EFFECTS	-20	-55	-100	-44	-34	-10	-10	-26	-26	-25	-33	-16	-19	-23	-34	-11	-20	-19	-29	-25	-29	-32	-36	-58	-50	-25	0	-5	-10	-10	-10	-10	-5	-5	-5	0
EMPLOYMENT AND BUSINESS EFFECTS	34	55	100	53	45	25	25	38	39	53	44	30	33	36	44	26	34	33	35	25	41	43	40	65	43	39	25	25	25	25	25	25	10	2.5	25	0
AVERAGE ANNUAL EQUIVALENT COST	0	-12	-71	0	0	37	37	0	0	0	-8	12	8	4	-9	18	7	8	-2	0	-4	-7	-11	-39	-7	-1	0	8	8	8	8	8	-10	-10	-10	50
CONSTRUCTION FACTORS	-8.3	-21.7	-50.8	-28.2	-12.5	1.0	1.3	-12.1	-13.3	-13.3	-17.1	-4.6	-9.2	-10.4	-17.1	-5.4	-10.4	-11.7	-19.8	-20.8	-21.3	-10.0	-31.7	-31.7	-27.9	-17.9	-2.2	-4.2	0	0	0	0	2.5	.3	-3.8	0
TRANSPORTATION	-20	-20	-70	-50	-10	0	0	-15	-20	-20	-15	-5	-10	-15	-15	-15	-15	-20	-40	-60	-45	-40	-60	-60	-60	-5	0	-10	0	0	0	0	0	0	0	0
ECONOMIC EFFECTS	0	4.0	0	0	0	2.5	2.5	0	0	0	0	0	0	0	0	0	0	0	-5	6.0	0	0	0	0	9.0	0	-5.0	0	0	0	0	0	7.5	2.5	0	0
PUBLIC FISCAL EFFECTS	-10	-51	-100	-47	-30	0	0	-25	-25	-25	-40	-10	-20	-20	-40	-5	-20	-20	-29	-26	-30	-35	-50	-50	-32	-50	-10	-25	0	0	0	0	-10	-5	-10	0
EMPLOYMENT AND BUSINESS	10	59	100	47	30	5	5	25	25	25	40	10	20	20	40	5	20	20	30	38	30	35	50	50	50	50	0	25	0	0	0	0	25	10	10	0
LOCAL PUBLIC SERVICE SYSTEMS	-10	-55	-100	-47	-30	0	0	-25	-25	-25	-40	-10	-20	-20	-40	-5	-20	-20	-30	-25	-30	-35	-50	-50	-50	-50	0	-5	0	0	0	0	-5	-5	-5	0
NUMERICAL AVERAGE OF RATINGS*	3.6	-4.0	-20.0	-26.0	1.9	8.9	9.1	13.7	9.5	2.4	1.9	-2.5	-.3	-1.0	7.3	-4.1	-1.7	-6.5	-11.7	-12.3	-13.4	-9.3	-10.0	-5.5	-6.7	-2.9	12.0	9.3	7.6	8.6	8.2	6.4	4.0	2.2	1.4	12.8
WEIGHTED AVERAGE OF RATINGS**	1.95	1.01	-4.60	-17.83	6.38	7.38	6.87	18.28	12.09	8.01	4.96	-.64	.77	-.06	11.16	-4.12	-.74	-6.56	-9.04	-8.11	-8.62	-4.37	-4.33	-6.09	-2.87	-1.80	10.38	5.53	3.95	5.68	4.03	.26	7.38	3.00	2.81	12.78

-28.1 WEIGHTED RATINGS FROM S.E.S. COMPUTER PROGRAM

-35 UNWEIGHTED RATINGS

* TOTAL OF ALL RATINGS DIVIDED BY THE NUMBER OF RATED ITEMS (32)

** CATEGORIES AND SUBCATEGORIES WEIGHTED TO REFLECT RELATIVE IMPORTANCE

Table M-7
Planning Precepts

TABLE B-6. PLANNING PRECEPTS	
WATER DEMANDS AND TIMING	Each eligible plan shall be capable of supplying sufficient water to meet the expected service area demands for water at all times up to the year 2000 (within dry-year deficiency limitations provided for in the SWP and CVP contracts or as they may be proposed for revision). Each plan shall also be capable of satisfying the probable maximum demands projected through the year 2000 by merely shifting the dates of construction of key components or programs.
SYSTEM COMPATIBILITY	Any component added to the existing SWP and CVP systems should be compatible with those systems and also be able to be incorporated into a complete plan for meeting the demands of the year 2000 without the necessity for abandonment of that component or any other component in the future.
STATE OF THE ART	Any plan proposed shall contain components which are within engineering technology now available, but be flexible enough to accept substitution with the advent of new engineering technology.
WATER RIGHTS AND OTHER LEGAL ASPECTS	Any plan, during its various stages of implementation, shall be compatible with existing water right permits for the SWP and CVP and with all other legal requirements.
WATER QUALITY	Each eligible alternative plan, during its various stages of implementation, shall be capable of complying with applicable State and Federal Delta water quality standards (as they may be from time to time modified) and with SWP and CVP export water quality criteria.
FISH AND WILDLIFE	No component added to the existing SWP and CVP systems shall preclude the eventual attainment of the fish and wildlife objectives.
FLOOD CONTROL	Any plan shall maintain or improve the flood-carrying capacity of Delta channels or include alternative means for conveying flood flows so as to reduce or prevent any material increase in the threat of flooding Delta lands. In this regard, any proposed changes to Delta channels or levees should be made compatible with recommendations in DWR Bulletin No. 192, "Plan of Improvement of the Delta Levees," May 1975.
NAVIGATION	Any plan shall maintain the use of Delta waterways for commercial, recreational, and military navigation. Any proposed change in present conditions will be governed by requirements of the Corps of Engineers and Coast Guard in their capacities of issuing permits for any project affecting navigable waters.
SEEPAGE AND DRAINAGE	Any alternative plans shall provide for control of any increase in seepage or drainage to Delta lands that may be caused by construction and operation of Delta facilities.
GROUND WATER	Ground water requirements imposed by any alternative plan shall be such that existing long-term overdrafts are not increased.

Table M-8
Components Comprising the Alternative Plans

COMPONENT	PLAN 1 "No Project"	PLAN 2	PLAN 3	PLAN 4	PLAN 5	PLAN 6	PLAN 7	PLAN 8	PLAN 9	PLAN 10
EXISTING FACILITIES										
SWP & CVP Facilities	•	•	•	•	•	•	•	•	•	•
New Melones Reservoir (under construction)	•	•	•	•	•	•	•	•	•	•
Auburn Reservoir (under construction)	•	•	•	•	•	•	•	•	•	•
DELTA WATER TRANSFER ALTERNATIVES										
Peripheral Canal		•								•
North Stub Canal – South Stub Canal			•							
North Stub Canal – South Stub Canal/Future Connection				•						
Mathena Landing Isolated Canal					•					
Mathena Landing Cross-Channel – South Stub Canal						•				
Mathena Landing Cross-Channel – South Stub Canal/Future Connection							•			
North Stub Canal – Enlarged Clifton Court Forebay								•		
North Stub Canal – Enlarged CCF/Future Connection									•	
OTHER DELTA COMPONENTS										
Environmental Monitoring	•	•	•	•	•	•	•	•	•	•
Four – Agency F&W Agreement (limits on Delta Diversions)		•	•	•	•	•	•	•	•	•
SWP – CVP Operation Agreement		•	•	•	•	•	•	•	•	•
Federal Participation in Delta Protection		•	•	•	•	•	•	•	•	•
Delta Water Agency Contracts		•	•	•	•	•	•	•	•	•
Review and Revision of Delta Water Quality Standards		•	•	•	•	•	•	•	•	•
Install Four Pumps in Delta Pumping Plant (SWP)		•	•	•	•	•	•	•	•	•
Completion of Delta Fish Protective Facility (SWP)		•	•	•	•	•	•	•	•	•
South Delta Water Quality Improvement Facilities		•	•	•	•	•	•	•	•	•
Relocation of Contra Costa Canal Intake		•	•	•	•	•	•	•	•	•
Suisun Marsh Facilities		•	•	•	•	•	•	•	•	•
Western Delta Overland Water Facilities										•
SOUTH OF DELTA COMPONENTS										
Water Conservation		•	•	•	•	•	•	•	•	
Waste Water Reclamation		•	•	•	•	•	•	•	•	
Enlargement of East Branch California Aqueduct		•	•	•	•	•	•	•	•	
Mid-Valley Canal		•	•	•	•	•	•	•	•	•
Los Vaqueros Reservoir		•	•	•	•	•	•	•	•	
Storage in Southern California Ground Water Basins		•	•	•	•	•	•	•	•	
Storage in San Joaquin Valley Ground Water Basins		•	•	•	•	•	•	•	•	
NORTH OF DELTA COMPONENTS										
Marysville Reservoir		•	•	•	•	•	•	•	•	•
Cottonwood Creek Project		•	•	•	•	•	•	•	•	•
Sacramento Valley Ground Water		•	•	•	•	•	•	•	•	
Glenn Reservoir – River Diversion		•	•	•	•	•	•	•	•	
Dos Rios Reservoir										•
RELATED ACTIONS										
Improved Delta Levee Maintenance	•	•	•	•	•	•	•	•	•	•
Fish Screens on In-Delta Diversions		•	•	•	•	•	•	•	•	•
Deepening Baldwin and Stockton Ship Channels		•	•	•	•	•	•	•	•	•

Table M-9
Summary of Composite Plan Ratings

RATED ITEMS	PLAN NO. 1 No Project	2 Peripheral Canal	3 North Stub - South Stub	4 North Stub - South Stub - Future Isolation	8 North Stub - Enlarged Clifton Court	9 North Stub - Enlarged CCF - Future Isolation
SYSTEM EFFECTIVENESS	-11.4	-11.9	8.3	10.4	9.4	10.1
IMPLEMENTABILITY	10.0	-6.3	-2.5	-5.5	-.8	-6.3
PUBLIC ACCEPTANCE	-20.0	10.0	12.5	12.5	22.5	15.0
PUBLIC ENTITIES	-25	40	30	35	25	35
CITIZEN AND ENVIRONMENTAL GROUPS	-15	-20	-5	-10	20	-5
FINANCIAL IMPLEMENTABILITY	100	-44	-30	-39	-35	-44
LEGAL - INSTITUTIONAL	-50	15	10	10	10	10
FLEXIBILITY WITH TIME	-56.6	8.4	-4.0	8.1	-2.7	8.1
NEW TECHNOLOGY	-50	-35	-35	-35	-35	-35
NEW STANDARDS	-60	38	-2	35	-3	33
CHANGING NEEDS	-60	23	25	25	30	27
RELIABILITY	0	35	30	30	30	30
ADEQUACY OF SUPPLY	-37.0	49.6	35.8	43.3	34.6	40.8
DELTA	-20.0	22.5	7.5	15.0	7.5	12.5
WATER QUALITY	-25	-5	-15	-10	-10	-10
WATER QUANTITY	-15	50	30	40	25	35
SERVICE AREA	-54.5	77.5	65.0	72.5	62.5	70.0
WATER QUALITY	-10	95	70	85	65	80
WATER QUANTITY	-99	60	60	60	60	60
PHYSICAL ENVIRONMENT	-8 5	13.5	-3.2	13.1	-10.8	11.3
BIOTA	-4.0	4.0	-21.0	3.3	-25.0	2.0
TERRESTRIAL ECOSYSTEMS	0	-6	-6	-6	-8	-8
AQUATIC ECOSYSTEMS	-10	20	-55	18	-65	16
SUISUN MARSH ECOLOGY	-2	-2	-2	-2	-2	-2
LAND FORM ALTERATION	-17.5	32.5	32.5	32.5	17.5	30.0
DRAINAGE AND FLOODING	-25	80	80	80	70	80
STABILITY AND EROSION	-10	-15	-15	-15	-35	-20
RESOURCE SUPPLY AND DEMAND	-20.0	-11.7	-11.7	-11.7	-11.7	-11.7
NET ENERGY USE	-25	-10	-10	-10	-10	-10
MATERIALS	-10	-15	-15	-15	-15	-15
SOCIO-CULTURAL FACTORS	-14.8	20.5	17.0	18.8	17.1	16.1
LAND USE AND DEMOGRAPHY	-15.0	-3.3	-6.0	-3.3	-8.0	-7.3
COMPATIBILITY WITH PLANNED LAND USE	-30	-15	-13	-14	-23	-27
COMPATIBILITY WITH RELOCATION PLANS	-10	18	8	17	12	18
DEMOGRAPHY	-5	-13	-13	-13	-13	-13
AMENITIES	-12.5	16.5	13.0	15.0	9.0	11.5
ARCH., PALEO. AND HIST. SITES	0	-50	-50	-50	-55	-55
RECREATION ACTIVITIES	-25	83	76	80	73	78
AESTHETICS	-15	65	60	60	65	60
ECONOMIC FACTORS	-41.8	17.4	21.4	19.4	19.4	17.4
PUBLIC FISCAL EFFECTS	-50	50	50	50	50	50
EMPLOYMENT AND BUSINESS EFFECTS	-50	50	50	50	50	50
AVERAGE ANNUAL EQUIVALENT COST	-30	-30	-20	-25	-25	-30
CONSTRUCTION FACTORS	-7.5	-6.5	-6.5	-6.5	-6.5	-6.5
TRANSPORTATION	0	-25	-25	-25	-25	-25
ECONOMIC EFFECTS	-10.0	7.5	7.5	7.5	7.5	7.5
PUBLIC FISCAL EFFECTS	-10	-10	-10	-10	-10	-10
EMPLOYMENT AND BUSINESS	-10	25	25	25	25	25
LOCAL PUBLIC SERVICE SYSTEMS	-10	-10	-10	-10	-10	-10
NUMERICAL AVERAGE OF RATINGS*	-19.9	13.8	8.5	12.8	7.2	11.5
WEIGHTED AVERAGE OF RATINGS**	-19.31	16.91	9.41	15.28	7.33	13.82

[-19.9] WEIGHTED RATINGS FROM S.E.S. COMPUTER PROGRAM
[-35] UNWEIGHTED RATINGS
* TOTAL OF ALL RATINGS DIVIDED BY THE NUMBER OF RATED ITEMS (32)
** CATEGORIES AND SUBCATEGORIES WEIGHTED TO REFLECT RELATIVE IMPORTANCE

Table M-10
Proposed Program, Delta Alternatives Study Status, October 1976

COMPONENT	COMMENTS
DELTA PROTECTION PROGRAM	
ENVIRONMENTAL MONITORING	Monitor water quality and fish and wildlife resources.
FOUR-AGENCY FISH AND WILDLIFE AGREEMENT	(DWR, USBR, DFG, & USFWS) specifying needs and means of protecting fish and wildlife.
SWP CVP OPERATION AGREEMENT	Spell out responsibility of the two projects in meeting Delta and and project needs.
LIMITS ON DELTA DIVERSIONS	Low in dry years, intermediate in normal years, and high in wet years.
REVIEW AND REVISION OF DELTA WATER QUALITY STANDARDS	To assure criteria for protecting the Delta constitutes a reasonable, beneficial use of water.
FEDERAL PARTICIPATION IN DELTA PROTECTION	Provide for CVP to operate within the same rules for protecting Delta as SWP and federal participation in Delta Water Facilities and Suisun Marsh Protection.
SOUTH DELTA WATER QUALITY IMPROVEMENT FACILITIES	To distribute good quality water to areas that now have poor quality water.
SUISUN MARSH FACILITIES	To improve water quality for Marsh management.
FACILITIES SOUTH OF THE DELTA	
WATER CONSERVATION	Estimated that by year 2000, water conservation of 500 cubic hectometres (400,000 acre-feet) per year could be achieved.
WASTE WATER RECLAMATION	Estimated that by year 2000, 120 cubic hectometres (100,000 acre-feet) per year could be developed.
GROUND WATER STORAGE	To provide about 500 cubic hectometres (400,000 acre-feet) per year of firm project yield.
ENLARGE EAST BRANCH OF CALIFORNIA AQUEDUCT	To provide necessary aqueduct capacity to deliver water for storage in Chino Ground Water Basin.
LOS VAQUEROS RESERVOIR	To provide 200 cubic hectometres (160,000 acre-feet) per year of firm yield and other benefits.
MID-VALLEY CANAL	USBR Project to deliver water from California Aqueduct to east side of San Joaquin Valley to reduce existing ground water overdraft.
FACILITIES NORTH OF THE DELTA	
SACRAMENTO VALLEY GROUND WATER	To provide approximately 250 cubic hectometres (200,000 acre-feet) per year of firm yield.
COTTONWOOD CREEK PROJECT	USCE project to provide about 210 cubic hectometres (170,000 acre-feet) of firm yield for purchase by State.
MARYSVILLE RESERVOIR	USCE Project to provide about 200 cubic Hectometres (160,000 acre-feet) of water to offset loss from Ship Channel Projects.
GLENN RESERVOIR-RIVER DIVERSION	To provide 1.2 cubic kilometres (1 million acre-feet) of additional firm yield annually.
RELATED FACILITIES AND ACTIONS	
RELOCATE CONTRA COSTA CANAL INTAKE	To improve water quality and insure water supply for Contra Costa Canal; and to save water otherwise needed for water quality control at the present canal intake.
IMPROVE DELTA LEVEE MAINTENANCE	To protect Delta agriculture by reducing the threat of flooding and salt water intrusion from levee failure.
FISH SCREENS ON IN-DELTA DIVERSIONS	To help protect Delta fisheries by screening some of the 1.9 cubic kilometre (1.6 million acre-feet) in-Delta diversions.
DELTA WATER AGENCY CONTRACTS	To assure Delta Water Agencies of adequate quality water supply and provide repayment for project benefits.
SELECT ONE OF THREE ALTERNATIVE DELTA WATER TRANSFER FACILITIES	
NEW HOPE CROSS CHANNEL—SOUTH DELTA INTAKE CHANNEL	
NEW HOPE CROSS CHANNEL—ENLARGED CLIFTON COURT FOREBAY	
PERIPHERAL CANAL	

APPENDIX N
DOCUMENTS INCORPORATED BY REFERENCE

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DOCUMENTS INCORPORATED BY REFERENCE

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APPENDIX O
LIST OF PREPARERS

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This Environmental Impact Report/Environmental Impact Statement was prepared by the California Department of Water Resources, Division of Planning, 1416 Ninth Street, Sacramento, CA 95814 with assistance from the U.S. Bureau of Reclamation, Mid-Pacific Region, and the U.S. Fish and Wildlife Service, both at 2800 Cottage Way, Sacramento, CA 95825, the Department of Fish and Game, 4001 N. Wilson Way, Stockton, CA 95205, and the U. S. Army Corps of Engineers, 650 Capitol Mall, Sacramento, CA 95864. A list of persons who prepared various sections of the document, significant background material, or participated to a significant degree in preparing the document is presented below.

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U.S. Bureau of Reclamation

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Phillip Harrison	B.S. Fishery Biology minor Computer Programming Wildlife; Wildlife Biologist; 6 years in Fish and Wildlife Studies	Wildlife resources impact analysis
Richard DeHaven	B.S. Fish and Wildlife Biology Fish and Wildlife Biologist, Federal Projects Planning	Fish and Wildlife Research Evaluation of impacts to Fish and Wildlife

	Division; 5 years in Water Resources; 18 years involving Development Planning	

Department of Fish and Game

Name	Qualifications	Participation
Patrick Coulston	B.S. Fisheries Biology, M.S. Fisheries Science Associate Fisheries Biologist DFG; 14 years	Provided background material and impact analysis for fisheries resource
Sonja Hamilton	M.S. Marine Science Fishery Biologist; 4 years, DFG	Fisheries impact analysis

Consultants

Name	Qualifications	Participation
Dr. Johannes J. DeVries	Ph.D. Civil Engineering Program representative with Water Resources Center in U.C. system; 30 years	Consultant with Tide Gate Barrier Studies

APPENDIX P
WETLAND INVENTORY AND ANALYSIS

APPENDIX P
WETLAND INVENTORY AND ANALYSIS

In Chapter 4 several areas were identified in the north Delta area as having exceptional natural habitat values, including wetland restoration potential (Figure 4-1). The principal areas are the Delta Meadows, the Cosumnes/Mokelumne River confluence area, and the Stone Lakes basin, including Beach Lake, North Stone Lake, and South Stone Lake. These areas have historically served as overflow areas during floods, attenuating the largely uncontrolled runoff into the north Delta area.

The reduction in duration and areal extent of flooding associated with improved flood control may affect the distribution of flora and fauna in these areas (Chapter 5, Flood Control alternative analysis).

This appendix contains a sample of available resource inventories for these areas. Additional information will be assembled by DWR staff and by USFWS as part of its EIS for the proposed Stone Lakes Refuge.

FILE COPY

PRELIMINARY

PROJECT PROPOSAL

PROPOSED
STONE LAKES NATIONAL WILDLIFE REFUGE

SACRAMENTO COUNTY, CALIFORNIA

SEPTEMBER 1989

Introduction. In the early 1970s the U.S. Army Corps of Engineers (Corps) commenced design of the Morrison Creek Stream Group Project, Sacramento County, California. A National Wildlife Refuge (refuge) was authorized with this flood control project as a mitigation and enhancement feature. The refuge was to be established over the Corps' 7,800 acre flood retardation basin. In addition, the Corps planned to place restrictive flowage easements over an additional estimated 5,000 acres. Over the years the county and city of Sacramento implemented many of the Corps' flood control features, and the Corps abandoned the original project. Since the Corps no longer needs mitigation lands, the U.S. Fish and Wildlife Service (Service) will have to pursue acquisition on its own if a national wildlife refuge is still desired.

Nothing in this proposal is intended to alter any ongoing or proposed flood control policies or projects. Agencies charged with flood control responsibilities must understand that this proposal is subject to considerable further study. Even if the project is implemented, substantial private properties will remain in the area, and the Service lands will also require flood protection.

The additional lands would include valuable seasonal wetlands and California prairie. This acreage figure represents the total within the proposed boundary; it is possible that some of this land will never actually be acquired. The project will include a variety of fee title acquisitions, easements, and cooperative agreements.

The Concept Plan for Wintering Waterfowl Habitat Preservation - Central Valley California identifies these as important wetlands threatened by urban encroachment and requiring preservation.

Location and Size. The proposed refuge is adjacent to the city of Sacramento in the southwestern portion of Sacramento County on the northeast side of the Sacramento River-San Joaquin River delta. Generally, the lands are bounded by Morrison Creek, the Western Pacific Railroad alignment (now owned by Union Pacific), Lambert Road, and the abandoned Southern Pacific Railroad alignment. These lands drain into Snodgrass Slough which carries water to the Consumnes-Mokelumne River delta.

Description of Habitat. This area is a remnant of what was once a vast complex of permanently and seasonally flooded wetlands flanked by riparian forest and prairie. The native plant communities have been greatly changed by the effects of flood control and agricultural operations. Remnants of a variety of native plant communities still exist, particularly in the riparian scrub-shrub zones with willows, cottonwoods, and oaks.

The needlegrass grasslands that were probably native to many dryer sites may now be locally extinct. Grazing practices are the most likely cause of the decline of native grasslands and riparian forests. Control of grazing should aid in restoring the diversity and vigor of these areas.

Approximately 200 square miles of urban watershed discharge through the project area. Perennial lakes, sloughs, and streams cover approximately 1,200 acres. There are additional thousands of acres of seasonally flooded wetlands and vernal pools.

Aquatic bed does not appear to be well established in the permanently flooded wetlands, possibly the result of carp activities. Emergent vegetation, primarily cattails and bulrushes, is present around the edges of the larger lakes and widespread in the sloughs and seasonally flooded wetlands.

Most of the area surrounding South Stone Lake is presently farmed with rotational crops of alfalfa, wheat, and sugar beets. Increasingly the land is being converted to vegetable crops and vineyards. Land parcels in this area have substantial development such as homes, support buildings, and irrigation and drainage systems.

The area around North Stone Lake and to the east of Interstate 5 is largely pasture with some stream courses, small wetlands, and vernal pools. Vernal pools are found where water accumulates above the hardpan in a "perched" water table, during winter and spring. As the rainwater slowly evaporates, concentric rings, each of one particular plant species, bloom and die in a pattern of temporary succession. These vernal pools can provide important habitats and support 90 percent of the native plant species found in the area.

Major Wildlife Values. The area supports a variety of migratory and resident birds and a warmwater fishery. Over 140 species of birds, 26 mammals, 8 reptiles, 4 amphibians, and 27 fishes have been recorded on the area. Great-blue herons, great egrets, and cormorants nest on North Stone Lake.

The area provides an important link in the Pacific Flyway. The proposed refuge provides nesting, migration, and wintering habitat for 23 species of waterfowl. If the proposed area is managed as successfully as other refuges in central California, it could support 30 million waterfowl use days annually.

Endangered wildlife species using the proposed project area include American peregrine falcon, and possibly the Aleutian Canada goose. The area could, under proper management, support the least Bell's vireo. Candidates for Federal listing using the proposed refuge area include California black rail, giant Sierra garter snake, Sacramento splittail (a fish), and Boggs Lake hedge hyssop (an annual herb).

Related Resources. Though there are many State and Federal wildlife areas in the Central Valley, none are located in the Sacramento area. The nearest Federal areas are Sutter National Wildlife Refuge 50 miles to the north, San Pablo Bay National Wildlife Refuge 45 miles west, Antioch Dunes National Wildlife Refuge 30 miles southwest, and 90 miles to the south the Merced, San Luis, and Kesterson National Wildlife Refuges.

The closest State wildlife areas are Gray Lodge Wildlife Area 60 miles north, Grizzly Island, Lower Sherman Island, and Joice Island Wildlife Areas 35 miles southwest, and the Los Banos and Volta Wildlife Areas 100 miles south. The American River Parkway, an urban/rural parkway, is 5 miles north of the project area. The Nature Conservancy's Consumnes River Preserve is 4 miles south of the project area.

Threats. In little more than a century, wetlands in California have diminished to less than 10 percent of their historic acreage. These losses have occurred as a direct result of the agricultural, residential, commercial, and industrial development of California lands. The specific threats to the project area come from various quarters.

Commercial and residential development of large portions of the project area is imminent. Sacramento is the fastest growing area within California. Approximately 2,000 acres within the project area are proposed or approved for development which would adversely impact seasonal wetlands and vernal pools. Development interests are also pursuing the conversion of the lands north of the proposed refuge.

Hazardous Waste. A preliminary preacquisition contaminant survey was completed by the Sacramento Ecological Services Field Office in February 1989. The survey concluded that there are no data from the project area to confirm or deny the presence of hazardous wastes on lands proposed for acquisition. Discharges and runoff from agricultural, municipal, and industrial sites have the potential to disperse contaminants onto the proposed acquisition lands.

The Sacramento Army Depot, a superfund site, is located 6 miles upstream from the flood basin. Data on contamination of biota have not been collected; therefore, its impact is unknown. The decontamination role of the waste water treatment facilities, situated between the Sacramento Army Depot and the Beach/Stone Lakes basin, is presently unknown. A complete risk assessment with appropriate sampling should be performed prior to acquisition.

Justification and Funding. The proposed refuge offers an important opportunity to advance the specific objectives outlined in several of the Service's planning documents such as the North American Waterfowl Management Plan goal: "To improve the quality of publicly managed habitat and protect and restore 80,000 additional acres of wintering habitat for pintail and other waterfowl in the Central Valley of California."

It is anticipated that lands within this project will be acquired with monies from the Land and Water Conservation Fund.

Ownership and Type of Acquisition. Various public and private entities own the lands within the project boundaries. The public entities include: California Department of Parks and Recreation (State parks) which owns approximately 1100 acres encompassing North Stone Lake and a portion of the old Southern Pacific Railroad alignment; California Department of Transportation (Cal Trans) which owns 142 acres around Beach Lake; Sacramento County Department of Parks and Recreation (county parks) with approximately 1600 acres in the North Stone Lakes area; and Sacramento Regional Sanitation District (sanitation district) with approximately 3500 acres at the north end of the project. The remainder is in private ownership.

Cal Trans would like to dispose of its Beach Lake parcel.

The 2700 acres of county and State parks land at North Stone Lake have been managed by Sacramento County for several years. The land has been managed primarily for grazing, but there is increased interest in managing the land for wildlife values.

Sanitation District managers have expressed interest in managing their lands in cooperation with the Service.

A variety of acquisition options ranging from cooperative agreements to fee title acquisition is possible. To best meet Service objectives, it is anticipated that the Service will acquire title to some private lands and long term management agreements on State and local government holdings. Conservation easements may provide sufficient protection for some areas. There are some areas, especially east of Interstate 5, where existing development and high land costs may preclude acquisition.

DEPARTMENT OF THE INTERIOR
U.S. Fish and Wildlife Service

Notice of Intent to Prepare an Environmental Impact Statement for the establishment of a National Wildlife Refuge and protection of wetlands in south Sacramento County, California.

AGENCY: U.S. Department of the Interior, Fish and Wildlife Service

ACTION: Notice of intent and scoping period

SUMMARY: This notice advises the public that the U.S. Fish and Wildlife Service (Service) intends to gather information necessary for the preparation of an environmental impact statement (EIS) to explore the feasibility of establishing a National Wildlife Refuge and protection of wetlands on or near Stone Lakes in south Sacramento County, California. Comments received from all parties during an earlier environmental assessment scoping process will be incorporated into the scope and content of this EIS. Additional opportunities for public involvement will further define the scope of this EIS. This notice is being furnished pursuant to the National Environmental Policy Act (NEPA) regulations (40 CFR 1501.7) to obtain suggestions and information from other agencies and the public on the scope of issues to be addressed in the EIS.

SCOPING INFORMATION: Persons wishing to participate in the scoping process are encouraged to contact the U.S. Fish and Wildlife Service, Sacramento Realty Field Office as soon as possible. Interested agencies, organizations, and individuals are encouraged to participate in the public program for this project in order to identify and discuss major issues, concerns, and opportunities that should be addressed in the EIS. Written comments will also be accepted.

FOR FURTHER INFORMATION CONTACT: Mr. Peter J. Jerome, Refuge Manager, U.S. Fish and Wildlife Service, 2233 Watt Avenue, Suite 375, Sacramento, California 95825-0509, Telephone: 916-978-4420.

WRITTEN COMMENTS INFORMATION: Written comments should be received by November 15, 1990.

SUPPLEMENTARY INFORMATION: The preparation of an environmental assessment document to explore the feasibility of establishing a national wildlife refuge in south Sacramento County was initiated in March 1990. As a result of the scoping process, the Service has determined that the preparation of an Environmental Impact Statement is appropriate. Consistent with Departmental guidelines, the Service determined that the proposed project may result in potentially significant environmental effects related to the conversion of agricultural lands to wetlands.

Public workshops and meetings with local, state, and federal agencies have been conducted. The scope and content of these meetings, including existing issues and concerns documents, will be incorporated into the subsequent EIS scoping process. In addition, a range of preliminary alternatives that describe various acquisition objectives will provide the basis for environmental impact assessment.

BACKGROUND: The Central Valley of California encompasses an area of over 13 million acres which included an estimated four million acres of wetlands in the 1850's. Today, estimates of remaining wetlands in California's Central Valley have ranged from slightly less than 400,000 acres to 280,000 acres. The loss of wetlands coupled with declining waterfowl populations and other wetlands dependent species nationwide has resulted in management concerns at the local, state, and federal levels.

Since 1988, there has been heightened public interest in the protection of riparian areas in the Stone Lakes area. Separate Congressional and State Legislative appropriations resulted in widespread public support for the establishment of a National Wildlife Refuge. Other public and non-profit land managers have initiated wetland protection programs with the establishment of the Cosumnes Preserve to the south of Stone Lakes.

The Stone Lakes area represents remnants of a variety of native plant communities such as willow, cottonwood, and oak riparian forests. Seasonally flooded wetlands and vernal pools occur throughout the study area. The area provides an important component of the Pacific Flyway and provides wintering, nesting, and feeding habitat for 23 species of waterfowl. In addition, the area provides habitat for several species of flora and fauna that are candidates for the endangered species list.

The purpose and need for the establishment of Stones Lakes National Wildlife Refuge is supported by the wildlife and habitat values that characterize the area. The location of Stone Lakes to urban populations and development create opportunities for environmental education and interpretation but threaten the future availability of the habitat.

COUNTY OF SACRAMENTO
DEPARTMENT OF PARKS AND RECREATION

October 17, 1990

Steve Roberts
Department of Water Resources
P.O. Box 942836
Sacramento CA 94236-0001

Dear Steve:

Enclosed please find the executive summary of the North Stone Lake Resource Analysis that has been prepared for us by EA Engineering, Science, and Technology.

Also enclosed is a set of the tables that will appear in the completed document.

EA will be sending me the final, complete resource document within a week. I will forward a copy of it to you as expeditiously as possible.

I hope this information will assist your agency in the preparation of the EIR on the North Delta water facilities project.

Yours truly,

Lois Wright
Environmental Analyst

LW 1P950.000

3711 Branch Center Road • Sacramento, California 95827 • (916) 366-2061

NORTH STONE LAKE RESOURCE ANALYSIS - EXECUTIVE SUMMARY

INTRODUCTION

This document summarizes the results of an analysis of resources at the County of Sacramento, Department of Parks and Recreation's proposed North Stone Lake Wildlife Refuge. The analysis was conducted by EA Engineering, Science, and Technology (EA) from July 1989 until July 1990.

BACKGROUND

The proposed North Stone Lake Wildlife Refuge encompasses 2,570 acres owned or managed by the County of Sacramento. This figure includes the 132-acre lake surface, but not the 65.4 acres of borrow channel along the western edge of the property or the 16.4 acres of CALTRANS land north of the lake, at the Elk Grove Boulevard overpass of Interstate 5. The property lies within the lower basin of the Morrison Creek watershed, located south of the city of Sacramento. Originally an overflow area of the Sacramento River, the flood plain today consists of valley lands ranging in elevation from three feet below to 16.6 feet above mean sea level. The area is rich in riparian, wetland, and grassland vegetation, supports a diverse assemblage of fish, amphibians, reptiles, mammals, and birds, and is an important stop along the Pacific flyway for migratory waterfowl.

Activities of federal, state, and local agencies and organizations in the Sacramento Valley over the past decade have resulted in a number of programs and plans to protect and enhance wildlife resources. A consequence of the growing concern over habitat preservation and restoration are the various projects currently in existence or in the planning stages in the Central Valley, including the Nature Conservancy's Cosumnes River Preserve, the California Department of Fish and Game's proposed Yolo Basin Wildlife Area, and the U.S. Fish and Wildlife Service proposed Stone Lakes Wildlife Refuge. A cornerstone of the USFWS effort is the Sacramento County Department of Parks and Recreation's proposed North Stone Lake Wildlife Refuge. The purpose of this report is to serve as the basis upon which future land use planning and management decisions for the North Stone Lake property will be based.

GROUNDWATER HYDROLOGY

North Stone Lake occupies an area of the eastern Sacramento River flood plain that has been created by intermittent streams, which are eastern tributaries of the Sacramento River. The North Stone Lake area and vicinity are composed of a flat terrain at elevations from -3 to about 16.6 feet above msl.

Groundwater within the North Stone Lake property occurs in unconfined and confined conditions at depths of 30-40 feet. It flows eastward towards Franklin Blvd., where its elevation drops to 70 feet below msl, at a hydraulic gradient of about 0.002, about 12 feet per mile. The Stone Lake area itself has not been affected by intensive groundwater use, because of its closeness to the Sacramento River, which, through infiltration, prevents groundwater levels from declining significantly.

Groundwater contained in the water-bearing materials underlying most of Sacramento County is of excellent quality for irrigation and domestic use (DWR 1974). In the Stone Lakes area it has a calcium--magnesium bicarbonate character. The concentrations of iron and manganese in groundwater in the study area do not constitute a public health hazard, but iron and manganese tend to precipitate as insoluble hydroxides and stain laundry and porcelain fixtures, and they change the odor of the water and cause an unpleasant taste.

To provide drinking and potable water from a well in the proposed Stone Lake Wildlife Refuge, a well 150-200 feet in depth would have to be constructed west or northwest of North Stone Lake, where stream channel deposits occur, in a place that would be accessible to a drilling rig.

SURFACE WATER HYDROLOGY AND FLOODING

North Stone Lake lies within the Morrison Creek drainage basin at the north end of the Sacramento/San Joaquin Delta in central California. Flooding of the Beach/Stone Lakes basin is common, with damaging floods occurring on the average of once every three years.

The borrow channel between the site and the Southern Pacific Railroad (SPRR) tracks acts as a conduit between Lower Beach Lake, North Stone Lake, and South Stone Lake. When North Stone Lake water surface elevation is 5 feet or more above msl, water flows through the North Stone Lake drain, under Hood-Franklin Road, into South Stone Lake. Water from the borrow channel and South Stone Lake rejoin in the marsh south of South Stone Lake and continues downstream, under Lambert Road, into Snodgrass Slough, a backwater of the Cosumnes and Mokelumne Rivers.

The Lambert Road structure,located south of South Stone lake, was built by local landowners in 1920 and consists of a bridge with several flapgates, designed to prevent backwaters in Snodgrass Slough from flowing upstream into the Beach/Stone Lakes basin. The bridge and flapgates have structurally deteriorated over the years and several of the flapgates, designed to prevent reverse flows, are stuck partially open, allowing water to flow from Snodgrass Slough into the Beach/Stone Lakes basin when Snodgrass Slough water surface elevations exceed those of South Stone Lake. Tidal effects are now detectable as far north as the levee separating Lower and Upper Beach Lakes and during severe storm events, Lambert Road is overtopped when local water surface elevations exceed 11.1 feet above msl. The Corps of Engineers has recommended the raising of Lambert Road and the reconstruction of the Lambert Road outlet structure to prevent flood flows from entering the Beach-Stone Lakes area from Snodgrass Slough, a backwater of the North Delta. Completion of the proposed Lambert Road facility will limit upstream flow into North Stone Lake to infrequent storm events and prevent reverse flow during nonstorm conditions.

The California Department of Water Resources and the U.S. Army Corps of Engineers are currently cooperatively conducting a North Delta Water Management study. Potential flood control measures could significantly lower the water surface elevation in Snodgrass Slough and in turn, lower flood levels in the Beach-Stone Lakes area.

Continued strengthening and raising of Delta levees will reduce the potential for levee failures, could result in higher Delta water levels, which in turn could result in increased flood water levels in the Beach-Stone Lakes area.

The primary factors affecting water surface elevations at North Stone lake therefore, are: (1) the rate of inflow from Morrison Creek and local tributaries, (2) the water surface elevation of Snodgrass Slough, (3) the water surface elevation in the Cosumnes River floodplain, (4) the periodicity of water surface fluctuations, (5) the available water storage volume, (6) flow constrictions within the local hydraulic network, (7) the elevation of the Lambert Road levee and bridge, and (8) pumping from the North Stone Lake and Beach Lakes vicinity.

WATER QUALITY

Urbanization and agricultural practices in the Morrison Creek basin have resulted in maintenance of a low summer flow, derived principally from lawn irrigation, wastewater flows from urban areas, and agricultural return flows. These sources may have significant impacts on water quality.

USACE measurements of water quality within the Morrison Creek Basin from 1982 through 1984 indicate that inorganic chemical concentrations exceeded water quality criteria designed for the protection of human health and freshwater aquatic life.

EA conducted a water quality monitoring study at North Stone Lake in 1989-90. Heavy metal concentrations in water samples did not substantially exceed criteria for the protection of freshwater aquatic life. Arsenic levels in all samples however, exceeded the criterion for protection of human health.

SOILS

The soils map (Map 5) at the end of the resource analysis document can be used to evaluate: (1) alternative sites for small structures; (2) alternative routes for access roads and trails; (3) alternative sites for septic tank absorption fields; (4) proposed drainage systems, irrigation systems, ponds, terraces, and other water management structures; and (5) and identify areas of the site where more detailed soil investigations are needed.

Table 5-2, which is included in this summary, shows the degree and kind of soil constraints that affect above-ground structures, roads and trails, shallow excavations, and septic tank absorption fields. Limitations are considered slight if soil properties and site features generally are favorable for the indicated use and constraints are minor and easily overcome; moderate if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize soil constraints; and severe if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies also may be required where soil constraints are severe.

Soil limitations in the North Stone Lake area are generally severe for above-ground structures and all-weather roads. Slight limitations for above-ground structures exist in soil units mapped as Tinnin loamy sand on isolated mounds in the southwestern portion of the study area.

Soil constraints are generally severe for paths and trails in the North Stone Lake area, except in relatively small areas of Clear Lake, Tinnin, and Galt soils, where limitations are moderate. Construction of paths and trails for facilities maintenance and recreational use generally requires little or no cutting and filling.

Soil limitations for shallow excavations in the North Stone Lake area are generally moderate to severe. Shallow excavations are holes or trenches dug to a maximum depth of 5 or 6 feet for utility lines, irrigation ditches, or other purposes.

Soils in the North Stone Lake area have severe limitations for septic tank absorption fields.

Soils in the North Stone Lake area generally have moderate to severe limitations for use as embankment fills.

TABLE 5-2 SOIL LIMITATIONS FOR BUILDING SITE DEVELOPMENT AND SANITARY FACILITIES IN THE NORTH STONE LAKE AREA, SACRAMENTO COUNTY, CALIFORNIA[a]

Soil Type	Above-Ground Structures	All-Weather Roads	Paths and Trails	Shallow Excavations	Septic Tank Absorption Fields
Fluvaquents	Severe (flooding)	Severe (flooding)	Severe (flooding)	Severe (flooding)	Severe (flooding)
Egbert clay, drained	Severe (low strength, flooding, skrink-swell)	Severe (low strength, flooding, shrink-swell)	Severe (too clayey)	Moderate (too clayey, wetness, flooding)	Severe (flooding, wetness, percs slowly)
Egbert clay, frequently flooded	Severe (flooding, shrink-swell)	Severe (low strength, flooding, shrink-swell)	Severe (too clayey)	Moderate (too clayey, wetness, flooding)	Severe (flooding, wetness, percs slowly)
Clear Lake clay	Severe (flooding, shrink-swell)	Severe (low strength, flooding, shrink-swell)	Moderate (too clayey, flooding)	Severe (cut banks cave)	Severe (flooding, wetness, percs slowly)
Clear Lake clay, hardpan substratum	Severe (flooding, shrink-swell)	Severe (shrink-swell, low strength)	Moderate (too clayey)	Severe (cut banks cave)	Severe (percs slowly)
Dierssen sandy clay loam	Severe (flooding, shrink-swell)	Severe (shrink-swell, low strength, wetness)	Severe (wetness)	Severe (cemented pan, wetness)	Severe (flooding, cemented pan, wetness)
Dierssen clay loam	Severe (flooding, wetness, shrink-swell)	Severe (shrink-swell, low strength, wetness)	Severe (wetness)	Severe (cemented pan, wetness)	Severe (flooding, cemented pan, wetness)
Tinnin loamy sand	Slight	Slight	Moderate (too sandy)	Severe (cutbanks cave)	Severe (poor filter)
San Joaquin silt loam	Severe (flooding, shrink-swell)	Severe (shrink-swell, low strength)	Severe (erodes easily)	Severe (cemented pan)	Severe (cemented pan, percs slowly)

a. Source: Soil survey of Sacramento County, California (Tugel 1985).

TABLE 5-2 (Continued)

Soil Type	Above-Ground Structures	All-Weathered Roads	Paths and Trails	Shallow Excavations	Septic Tank Absorption Fields
Galt clay	Severe (flooding, shrink-swell)	Severe (low strength, shrink-swell)	Moderate (too clayey)	Severe (cemented pan, cutbanks cave)	Severe (cemented pan, percs slowly)
San Joaquin-Galt complex	See above[b]	See above	See above	See above	See above
Durixeralfs-Galt complex	No data[c]	No data	No data	No data	No data
Open Water	N/A	N/A	N/A	N/A	N/A

b. Areas mapped as San Joaquin-Galt complex consist of San Joaquin silt loam on low mounds and Galt clay in the intervening small depressions.

c. Areas mapped as Durixeralfs-Galt complex occur in a narrow strip along the west side of Interstate 5. They are altered soils for which no data on limitations have been described.

Construction of irrigation pipelines and drains may be limited by the presence of a cemented pan in the subsoil. The Egbert clays in the North Stone Lake area have been extensively developed for irrigated pasture.

VEGETATION AND VERNAL POOLS

A floristic and vegetation survey was undertaken in the North Stone Lake area to inventory and map existing vegetation and to determine whether any rare, threatened, or endangered plant species are present on the site.

Some 102 (46 percent) of the species and infraspecific taxa are non-native plants that have become established in the lowlands of central California or have been introduced on the site through cultivation.

Non-native Grassland: Non-native grassland is the predominant vegetation type in the North Stone Lake area, covering 81 percent of the site. Except for the annual tarweeds (Holocarpha virgata and Hemizonia luzulaefolia ssp. rudis), which become locally abundant in the fields northeast of the lake, very few native plants are found in the grasslands during the dry summer months. Yellow star-thistle (Centaurea solstitialis), a non-native weed has become locally abundant along the main access road south of the lake and elsewhere in the southwestern portion of the study area. It is unpalatable to livestock and troublesome to both hikers and equestrians.

The grasslands surrounding North Stone Lake have been used as livestock winter pasture for the past several decades, and presently, they do not support extensive stands of native perennial grasses. Native grasses, which are locally common to abundant over small areas in seasonally moist grassland, include creeping wildrye (Elymus triticoides), meadow barley (Hordeum californicum), and Lemmon's Canarygrass (Phalaris lemmonii). Valley saltgrass (Distichlis spicata var. nana), an indicator of saline soils, is also locally abundant (presumably on sites of old salt licks).

Northern Hardpan Vernal Pool -- True vernal pool vegetation is of limited distribution and extent in the North Stone Lake area. Naturally occurring pools were found at three locations in the eastern and northeastern parts of the study area. Other Shallow natural depressions occur in grassland more-or-less throughout the study area and are especially numerous on the low terrace landform of the northeast quadrant. Most of these grass-dominated depressions contained small areas of vernal pool vegetation.

The occurrence of vernal pools and similar habitats in the North Stone Lake area thus represents an opportunity to protect and enhance one of the state's most distinctive and threatened wetland ecosystems.

Valley Freshwater Marsh -- Freshwater marsh vegetation occupies permanently flooded areas on the western shore of North Stone Lake and across the bed of the lake's southern arm. It is also found along sections of the borrow channel that form the western boundary of the site and on the beds of three arms of this channel that extend eastward into the study area.

Great Valley Riparian Forest -- Riparian forest is of limited extent in the North Stone Lake area, but nonetheless it is one of the most important wildlife habitats on the site.

The largest stand of riparian forest in the study area is located on the south arm of North Stone Lake. Dominant trees include (in decreasing order of abundance) black willow (Salix gooddingii var. variabilis), yellow willow (Salix lasiandra), and Fremont's cottonwood (Populus fremontii).

Riparian forest is also found (1) along sections of the borrow channel forming the western boundary of the site and (2) on the margins of the three arms of this channel that extend eastward into the study area.

The riparian forest habitat at North Stone Lake is composed almost entirely of mature trees, with the seedling and sapling stages nearly absent and the understory similarly lacking a well-developed shrub layer. The skewed age-class structure and noticeable lack of regeneration of trees in the riparian forest of the area is probably related to long-term use of the site as livestock pasture. For example, the few young valley oaks that were found in the grasslands of the site have been browsed into rounded shrubs.

Irrigated Pasture -- Irrigated pasture lands cover most of the area between North Stone Lake and the western borrow channel. Irrigation water is obtained from the borrow channel by means of a series of small electric pumps and distributed through a concrete pipeline system. Water advances across the fields by gravity flow, eventually entering North Stone Lake.

Geomorphic and soils data suggest that those fields now in irrigated pasture at one time supported marshland vegetation. The fields have been used as summer livestock pasture for many years, and when properly managed they are well suited for this purpose. Without continued summer irrigation, however, the area will likely revert to annual-type grassland.

Introduced Trees -- Introduced trees are of limited distribution in the North Stone Lake area. A small stand of black locust trees is found along the main access road as it crosses the sandy mound, southwest of the lake. Although not native to the site or to California, these trees are an enduring landmark indicating the former homesite of the old Elliot ranch.

A planted hedgerow of Osage-orange (Maclura pomifera) trees extends for a quarter mile on the north side of Hood-Franklin Road, immediately west of the south entrance to the refuge.

Rare, Threatened and Endangered Plants. -- A previously undocumented occurrence of the dwarf downingia (Downingia humilis) was discovered within the North Stone Lake property in mid-April 1990. Downingia humilis is not currently listed as rare, threatened, or endangered. Although the available data suggest that D. humilis is probably not in immediate danger of extinction, a significant portion of its habitat has been eliminated by agriculture and other anthropogenic uses.

No other rare, threatened, or endangered plant species were found during field surveys in the North Stone Lake area.

WETLANDS

A wetlands assessment of the North Stone Lake area was conducted concurrently with the vegetation survey.

The lake bed is permanently flooded, but water levels fluctuate periodically in response to local flooding after heavy winter rains and a tidal influence extending northward into the area from Snodgrass Slough. The current summer water surface averages 2 feet above mean sea level.

Riverine wetlands -- habitat is found exclusively within the borrow channel forming the western boundary of the North Stone Lake area. Although the channel gradient is low, the banks are rather steep and there is no well-developed floodplain.

Forested Wetlands -- Forests of broad-leaved deciduous trees occur (1) on the south arm of North Stone Lake, (2) along sections of the borrow channel forming the western boundary of the site, and (3) on the margins of the three arms of this channel that extend eastward into the study area.

Emergent Wetlands -- Frequency and duration of inundation appear to be the most important determinants of vegetation structure and species composition in emergent wetlands of the North Stone Lake area.

The seasonally flooded emergent wetlands on the site offer valuable foraging habitat for migratory waterfowl, and yet they cover the smallest acreage of any wetland type in the North Stone Lake area.

WILDLIFE RESOURCES

The pristine Sacramento River Delta, in which the Beach/Stone Lakes basin is situated, was, before 1850, largely a tidal marshland of about 400,000 acres, surrounded by 200,000-300,000 acres of slightly higher lands and shallow backswamps behind natural alluvial levees. The area was covered with dense tules, willows, cottonwoods, sycamores, white alders, and valley oaks which, along with adjacent higher vegetation, teemed with more than 250 species of birds and mammals. The Sacramento River Delta was then one of the most significant areas of waterfowl concentration in California, supporting ducks, geese, swans, and other waterfowl in great numbers during the winter migration. In addition to many furbearers, such as river otter, bobcat, and grizzly bear, great herds of antelope, tule elk, and deer roamed in and around the Delta.

Soon after the onset of the gold rush of the 1850s, reclamation of the swamp and marshlands along the Delta waterways began. Subsequent levee-building and reclamation of the Delta lands irreversibly altered the physical appearance and function of the area. Reclamation eliminated much of the waterfowl and passerine nesting habitat of the ancestral Delta, gradually converting it into the complex system of managed channel and slough aquatic habitats, occasional remnants of riparian forests, and urban habitats which together now characterize the area.

The major wildlife habitats at North Stone Lake include the following:

1. Annual and perennial grasslands (AGS, PAS). This habitat type incorporates irrigated pasture and other grazing lands at North Stone Lake. These grasslands surrounding the lake and borrow channel provide important foraging habitat for raptors and other wildlife species and are used by ground-nesting passerine birds and waterfowl. They attract one of the most important concentrations of sandhill cranes in California.

2. Riparian forest and shrub-brush (VRI). Mature riparian forest, consisting of stands of large cottonwoods and willows, offer the most diverse habitat resources for birds and other wildlife. Their value is made even more significant by their limited distribution and by the added resources they provide to wildlife in adjacent habitats. Although the structural diversity and specialized microhabitats in riparian shrub-brush are fewer than in mature woodlands, that habitat is also heavily used by wildlife and is significant in maintaining many species of birds and mammals.

3. Freshwater emergent marsh (FEW). The nontidal marshes at North Stone Lake are small remnants of the "backswamp" overflow lands (seasonal floodplains) that once covered large expanses of the Delta behind natural berms and levees, and they may be significant vestiges of the "pristine" Delta. The density of vegetation in these marshes determines their use by wildlife. Dispersed stands may be used by shorebirds, while

denser stands can provide shelter for rails and wrens. Muskrat and beaver use such marshes for food and shelter and with sufficient areas of marsh and open water, beavers are less likely to use levees as lodge sites.

4. Channels and Open Water (LAC). These bodies of water were formed either as trapped, formerly tidal sloughs and old overflow channels in the floodplain or as part of marshes lying behind levees. The reduced flow in the quiet backwaters of the channels and lake permits an extensive floating plant community to develop, providing essential habitat for native resident fish, amphibian, reptile, bird, and mammal species.

The wildlife habitats present at North Stone Lake can support an unusually rich fauna, including a number of species listed in Table 8-2 (included in with this summary), that have some form of legal and/or protected status.

Fish -- Fish were sampled in November 1989 and June 1990. Maximum lake depth was never more than 8 feet (at the center of the lake), and water temperature was measured at 16 degrees C during the November sampling and 25 degrees C during the June sampling.

The numbers, mean lengths, and weights of the fish caught at North Stone Lake during these surveys are listed in Tables 8-5 and 8-6 of the resource analysis document.

Reptiles and Amphibians -- Amphibians and reptiles were either collected in pit traps in suitable habitat or by daily searches under logs and rocks. Western pond turtles were regularly observed basking in the sun on logs and rocks in the borrow channel and in the marshy area at the south end of the lake. The giant garter snake was observed at a few locations along the borrow channel and the lake edge.

Birds -- The first formal bird surveys at North Stone Lake were performed in November 1989. The bird community at that time of year (27 species observed) consisted mainly of migrating and resident waterfowl, foraging raptors (northern harrier, red-tailed hawk, American kestrel, and prairie falcon) and kingfishers, and of resident passerines (red-winged blackbirds, horned larks, savannah sparrows, and western meadowlarks). The species observed in the greatest numbers were usually found at the northern end of the lake and consisted mainly of migrating waterfowl. A small population of American white pelican (25) appeared to be resident in the area throughout the period.

Bird activity at the lake was again surveyed in January 1990. Winter-resident waterfowl were among the most typical of the 32 species observed. Raptors, including northern harriers, red-tailed hawks, American kestrels, prairie falcons, golden eagles, and short-eared owls were observed foraging over the grasslands.

By far the greatest species diversity (more than 80 species) and abundance of birds at North Stone Lake was observed during the spring. A pair of Swainson's hawks regularly foraged at North Stone Lake during the spring and early summer. An immature goshawk was observed at the rookery on several occasions during the spring and an accipiter "plucking post" was found littered with egret feathers and pieces of bone and flesh from recent kills. On one occasion, a second goshawk was observed flying and vocalizing over the rookery with the first. The tricolored blackbird was not observed during the spring of 1990, but a nesting colony was active between the borrow channel and the lake in late spring and early summer of 1989.

Mammals -- California voles, western harvest mice, and deer mice were the most common mammal species on the property. A badger den was found in the grassland area south of the bird rookery. Evidence of river otter activity was found along the borrow channel and the southern portion of the lake. Coyotes and foxes (red and gray) were observed on the site, along with

TABLE 8-2 SPECIAL STATUS SPECIES OBSERVED AT THE NORTH STONE LAKE AREA, 1989-1990

Common Name	Scientific Name	Status[a]
Aleutian Canada goose	*Branta canadensis*	FE
Tri-colored blackbird	*Agelaius tricolor*	2
Swainson's hawk	*Buteo swainsoni*	CT, 2
Giant garter snake	*Thamnophis couchi*	CT, 2
Western pond turtle	*Clemmys marmorata*	CSC, 2
American white pelican	*Pelecanus erythrorhynchos*	CSC
Double-crested cormorant	*Phalacrocorax auritus*	CSC
California gull	*Larus californicus*	CSC
Golden eagle	*Aquila chrysaetos*	CSC
Northern harrier	*Circus cyaneus*	CSC
Northern goshawk	*Accipiter gentilis*	CSC
Prairie falcon	*Falco mexicanus*	CSC
Yellow warbler	*Dendroica petechia*	CSC
American badger	*Taxidea taxus*	CSC
California tiger salamander	*Ambystoma tigrinum*	CSC

a. FE = Federally endangered species; 2 = Federal Category 2 candidate endangered species; CT = California threatened species; CSC = California species of concern.

beaver, muskrat, racoon, and skunk. Columbia black-tailed deer were seen in the riparian habitat along the borrow channel north of the lake.

The results of wildlife surveys at North Stone Lake indicate that the area currently supports a diverse community of fishes, amphibians, reptiles, birds, and mammals. While riparian and marsh habitats have been degraded by agricultural and livestock practices over the past decades, many of the grassland areas (except for vernal pools and temporary wetlands) do not seem to have suffered greatly from grazing activity. Considerable opportunity exists for enhancing and restoring riparian, freshwater marsh, and perennial grassland habitats on the site, and existing irrigated pasture could be planted to augment waterfowl food resources. Continued limited grazing, if properly administered on portions of the property, could stimulate seeding and growth of perennial grasses. Effective planning and management of the proposed North Stone Lake wildlife refuge will depend on careful consideration of the unique wildlife communities and species occurring there and the opportunities and constraints identified in the resource analysis presented here.

HISTORICAL AND CULTURAL RESOURCES

PAR ENVIRONMENTAL SERVICES, INC. (PAR) contracted with EA Engineering, Science, and Technology (EA) to conduct the cultural resources investigation.

Ethnography -- At the time of Euroamerican contact, the project area was occupied by members of the Plains Miwok ethnographic group. North Stone Lake was probably shared by the Gualacomne and Chupumne tribelets.

History -- Settlement and use of the marsh lands in the North Stone Lake vicinity was possible only as a result of the substantial reclamation effort that was started before 1856.

By 1903, land owners within or adjacent to the project included John Elliot (3,566 acres), William Johnston (385 acres) and the Farmers and Merchants Savings Bank (1,003 acres). John Elliot continued to expand his ownership and by 1923 his ranch encompassed some 4,396 acres around North Stone Lake.

Before 1915, growth in the region led to the construction of the Sacramento Southern Railroad (now owned by Southern Pacific Railroad) and the Great Western Power Company electric transmission line (located along the same alignment as the existing power line) (Punnett Brothers 1908; Weber 1914).

The property was in the Elliot family for approximately 60 years, until it was sold to a developer named McKeon in 1961. However, the County of Sacramento had designated the region around North Stone Lake as a permanent agriculture and recreation reserve in 1956, and no development occurred. Cattle grazing was permitted on the study site until the fall of 1989.

Resource Analysis -- A total of seven archaeological sites were recorded by PAR within the North Stone Lake project. Site records and a comprehensive cultural resources location map are provided in a separate report.

Artifactual materials noted at one site (NSL-S-1) include sparse flaked stone bifaces and debitage, fragments of baked clay objects, a soapstone pipe bowl fragment, and both Olivella and clam shell beads. Unmodified shell, fire cracked rock and several pieces of human bone (recently exposed by rodent activity) were also noted.

The remains of an historic occupation are evident on a small knoll south of North Stone Lake (NSL-S-2). The site contains domestic and structural artifacts, including bottle glass, ceramics (including Chinese brown ware), bricks, and cut nails, appear to date to the early part of the 1900s.

Remains from another site (NSL-S-5), located near the shore of North Stone Lake, includes one clam shell disk bead, one shard of baked clay, several pieces of unmodified clam shell, and small, unidentifiable bone fragments (some of which are burned).

The recorded resources represent a range of human occupation and use of the project area over the past 1,500 years or more.

A substantial body of scientific data is undoubtedly present at some of the prehistoric locations. There may also be strong Native American cultural ties to these former use areas, particularly those containing human burials. For these and other reasons, several of the archaeological sites at North Stone Lake warrant special management considerations.

The 1989 cultural resource investigation resulted in the recording of five newly discovered prehistoric and historical archaeological sites within the North Stone Lake project. Two previously recorded locations were relocated, and the site record forms were updated by PAR. Three additional prehistoric mounds that were noted in the vicinity in the past were not evident in 1989, although buried cultural materials may very well remain at these locations.

Several of the identified resources may be considered "important" under the definitions of the CEQA Guidelines or as eligible for inclusion in the NRHP (National Register of Historic Places).

LAND USE

The 2,570-acre North Stone Lake property is presently all under open space designation and use and predominantly uncultivated, including rangeland previously used for cattle grazing.

The Laguna Creek Ranch project, north of Elliot Ranch Road, is the largest site in transition from open space to urban use. Sites to the north and east of the North Stone Lake project area are also subject to urban development pressure.

Upcoming revisions to the County of Sacramento's land use plan will revise the Agricultural-Recreational Reserve category to Resource Conservation. This Resource Conservation designation may be applied to the agricultural lands immediately east of North Stone Lake (both north and south of Hood-Franklin Road) and to areas farther south. In addition, the new land use plan is creating a Natural Preserve designation to be applied to both North Stone Lake and South Stone Lake and along Morrison Creek.

Circulation and Access-- Access to the site is currently limited to two gates. One entrance is at the western edge of the paved overcrossing of I-5 at the Elk Grove Boulevard extension (south of Elliot Ranch Road). Another access point is a gate off Hood-Franklin Road, 2,560 feet due east of the old Southern Pacific Railroad (now the State Railroad Museum Railroad) tracks. Interior access from the two gates consists of unimproved private roads.

Roads -- Hood-Franklin Road, from the community of Hood to I-5, is a planned arterial. Hood-Franklin Road East, from I-5 to the community of Franklin at Franklin Boulevard, is planned as a thoroughfare beyond the year 2000. From Hood-Franklin Road, at the community of Franklin northward to Elk Grove Boulevard, Franklin Boulevard is a planned arterial with four lanes and 55 mph speed limit.

Elliot Ranch Road is a two-lane local street that is planned to remain a local street. It connects the Elliot Ranch (Lakeside) and Laguna Creek Ranch development projects with Highway 99.

I-5 is operating at or above current capacity. It will need to be expanded in the 1990s if growth occurs as projected in southern Sacramento County.

Railroads -- The California State Railroad Museum tracks form much of the project's western boundary. The tracks are to be refurbished for an excursion railway between Old Sacramento and the community of Hood, 6 miles south of Freeport. The railway is not yet in operation.

Future Facilities -- A significant transportation project within the North Stone Lake study area is the proposed Elk Grove Boulevard interchange with I-5. No public access is to be provided to the west (South-bound) side of I-5 at the Elk Grove interchange.

The Hood-Franklin Road Bridge is proposed to be replaced with a new bridge, and the road realigned.

Sacramento County's Major Street and Highway Plan does not indicate any extensions of existing roads into the North Stone Lake site.

Sacramento County is in the process of revising the Land Use Element of the General Plan. The draft Land Use diagram may indicate potential Park and Ride facilities at the three I-5 interchanges affecting North Stone Lake: Hood-Franklin, Elk Grove, and Laguna. The compatibility of these potential parking lots with the overall plan for North Stone Lake will need to be evaluated.

Bikeways -- There are no completed or proposed bikeways in the North Stone Lake property.

Despite transfer of the North Stone Lake property to public ownership in the early 1970s, public access to the site has remained restricted.

With the exception of a refuge sign, two locked steel gates, and a few roads, there are no developed recreational facilities at the North Stone Lake site.

RECREATION

In addition to its open space values, the North Stone Lake property offers the potential for unique recreational and educational experiences associated with its outstanding display of natural resources. North Stone Lake offers one of the few remaining examples of the Central Valley's natural landscape. The site is one of the last remaining natural freshwater lake habitats in the Central Valley, and it supports one of the most unique and diverse populations of birds, fish, and animals in the state (The Resources Agency of California 1972). More than 100 different bird species have been identified in the area. The area's aquatic habitat produces an impressive variety and abundance of fishery resources, and the site's riparian areas represent remnants of the diversified plant communities once typical of California's Central Valley. The opportunities for observation, study, and interpretation of the area's unique and varied flora and fauna are outstanding.

Excellent opportunities exist for passive recreational and educational pursuits such as enjoying the aesthetics of the area, seeking open space and solitude, and observing wildlife. Opportunities for more active forms of recreation such as fishing, hunting, boating, and a variety of trail uses may also exist at the site.

The greatest opportunities at the site, in terms of high-value recreational experiences, are for nature study and interpretation oriented towards the site's unique wildlife and riparian environment. These recreational uses represent opportunities not readily available elsewhere in the region.

AESTHETIC AND VISUAL RESOURCES

The lake itself, the associated riparian vegetation and marshland, and the wildlife species supported by such habitats are the primary scenic attributes of North Stone Lake. Although more common and less scenic than the lush riparian forest, the open valley grasslands that make up a large majority of the site provide an appropriate backdrop, as well as a sense of open space and a reprieve from the dense urban development which threatens to surround the site.

The Stone Lakes region is an almost pristine example of one of the nine natural landscape provinces in California, the Great Valley Province.

There are two vista points that can be seen from several areas of the North Stone Lake property. There are distant views of Mount Diablo to the south that can be seen from most of the open grassland areas. There are distant, panoramic views of the Sierra Nevada Mountain Range to the east, visible on clear days from most of the site.

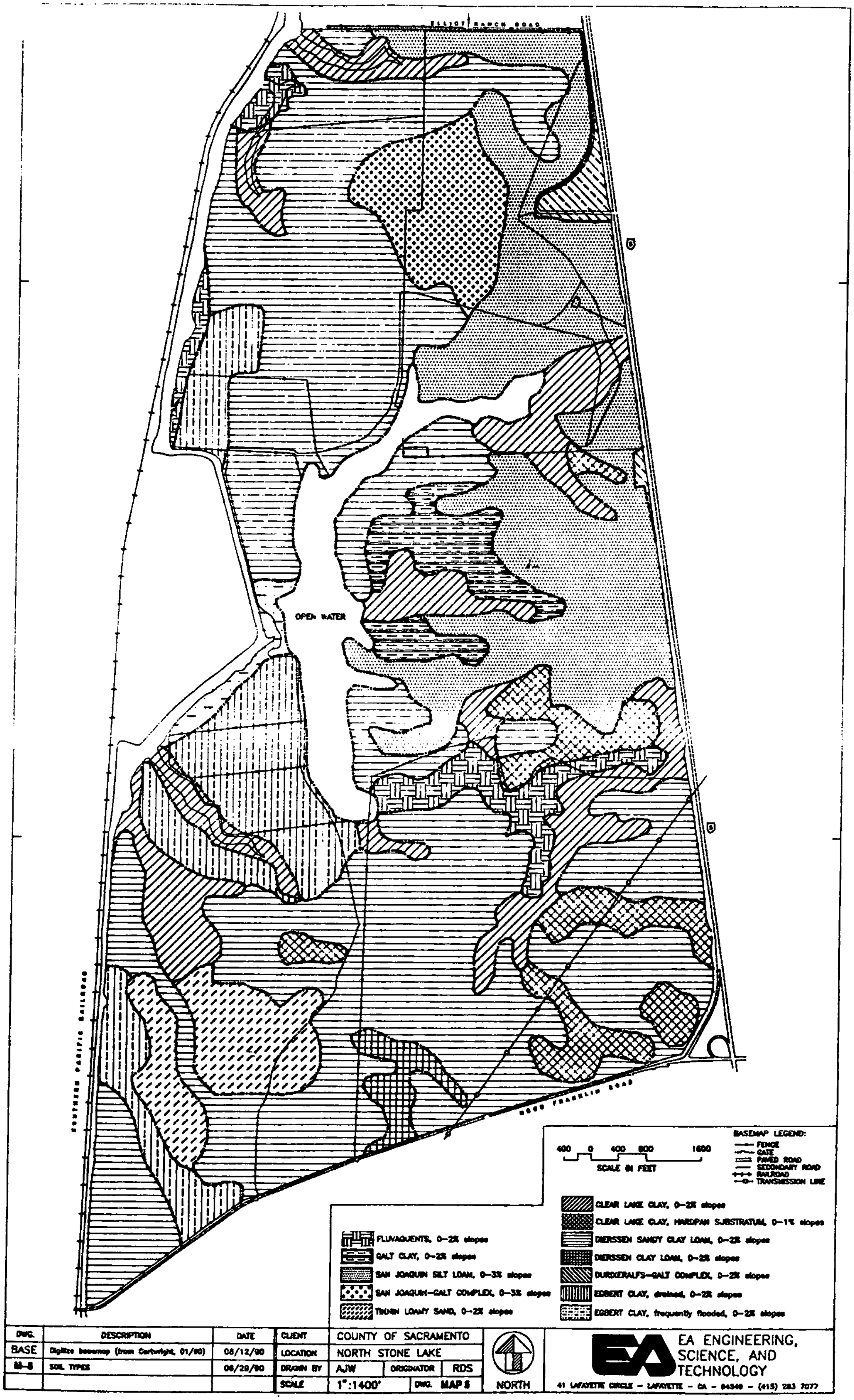
The bird rookery on the southern portion of the lake, the grove of Locust trees located north of the Hood-Franklin Road gate, and vernal pools scattered throughout the grassland areas are features considered to be of special aesthetic value.

The two major negative features are the Pacific Gas and Electric (PG&E) 230-kV transmission line that traverses the southeast corner of the site, and Interstate 5 (I-5), which forms the western site boundary.

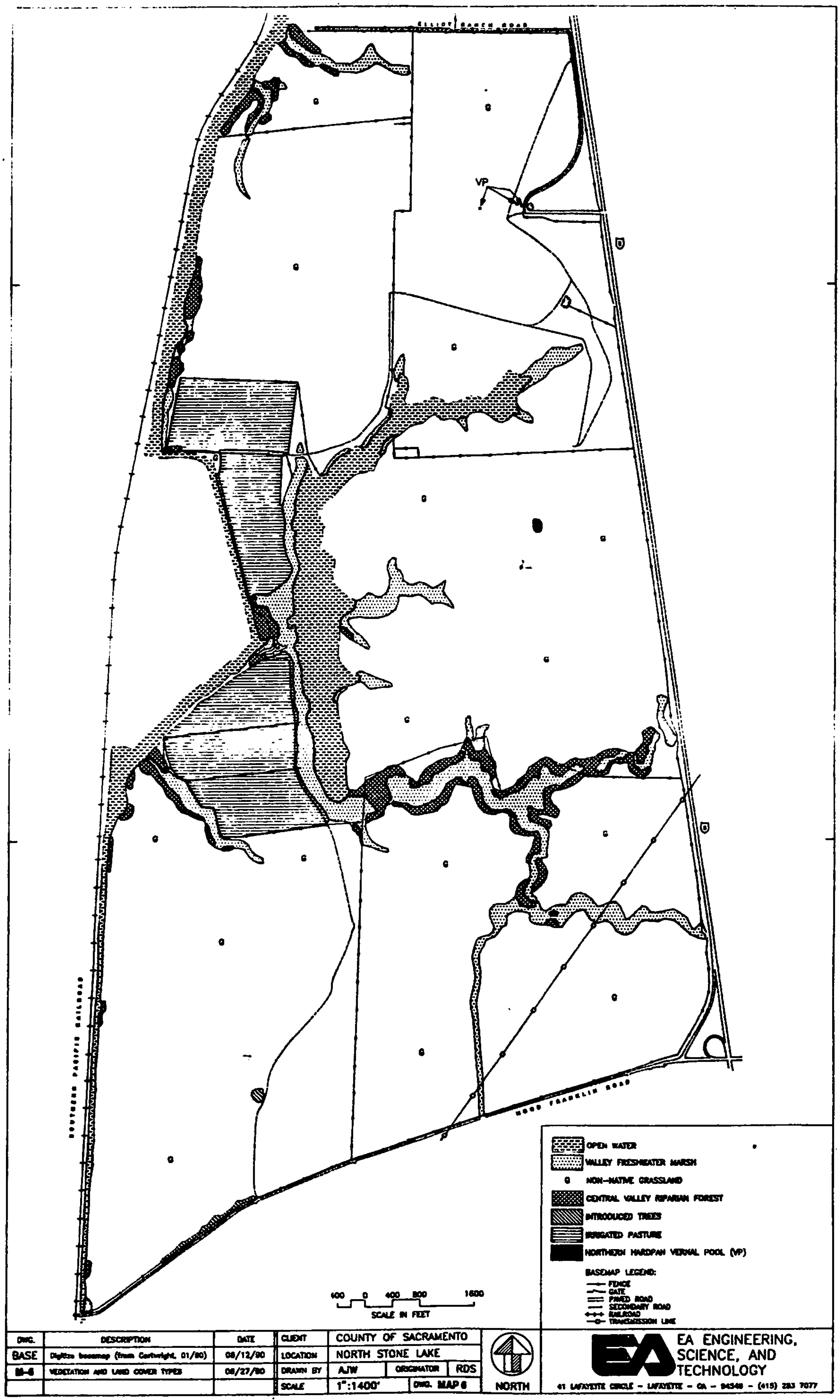
The area with the greatest positive auditory character is the bird rookery. This area supports breeding activities throughout much of the spring and early summer for hundreds of birds, including blue and black-crowned night herons and great and snowy egrets. The intense activity associated with mating, nesting, and rearing produce a cacophony of bird sounds rarely experienced in the surrounding environs of the Valley. Because of the uniqueness of this experience, the auditory sounds associated with the rookery are considered to be a positive auditory feature.

Another common auditory resource experienced throughout most of the site outside the rookery and the I-5 corridor is the relative absence of noise--often referred to as "peace and quiet."

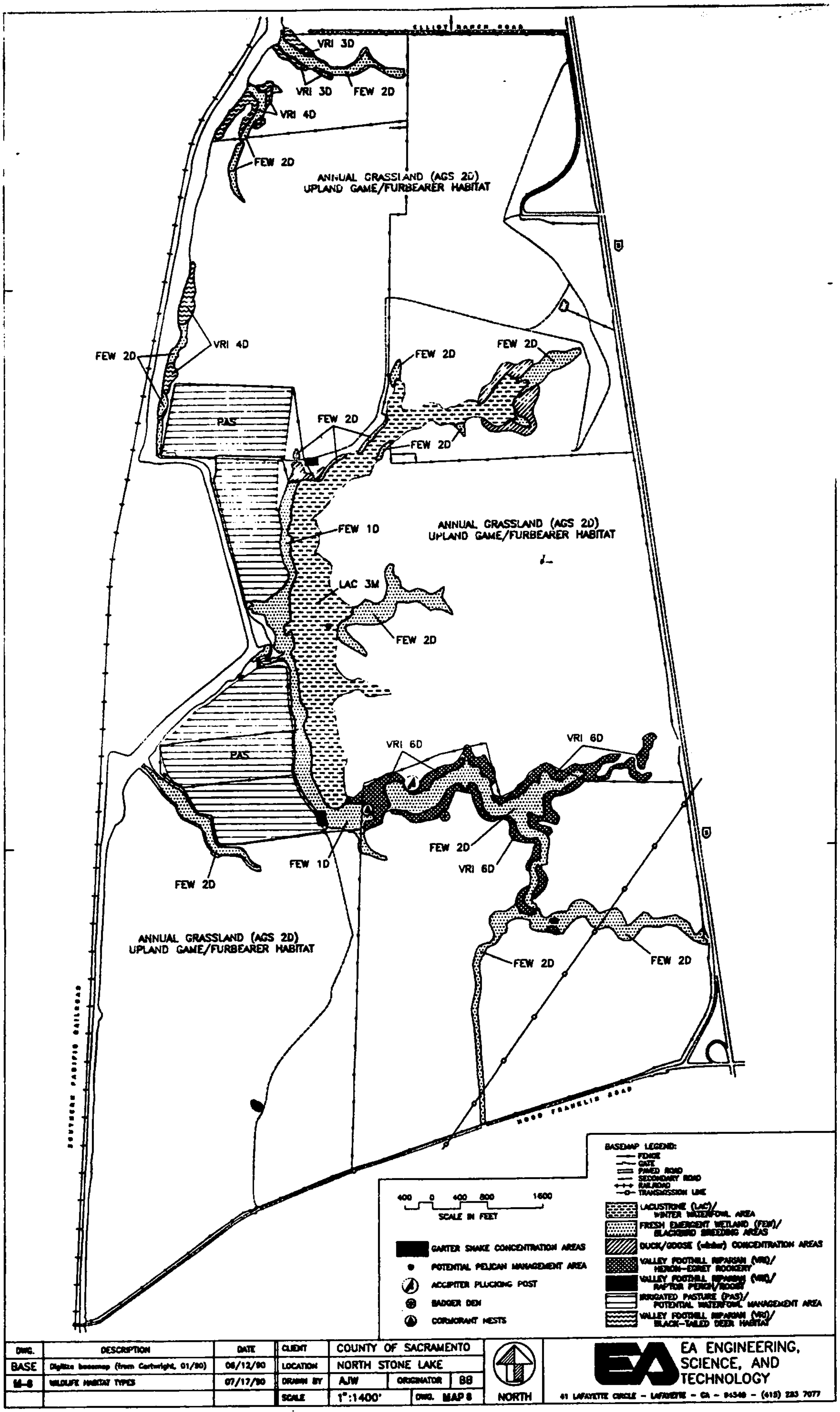
The one major negative feature that affects the auditory experience of the North Stone Lake site is the Interstate 5 traffic corridor.


ELLIOT RANCH ROAD
OPEN WATER
SOUTHERN PACIFIC RAILROAD
HOOD FRANKLIN ROAD
BASEMAP LEGEND:
FENCE
GATE
PAVED ROAD
SECONDARY ROAD
RAILROAD
TRANSMISSION LINE
400 0 400 800 1600
SCALE IN FEET
FLUVAQUENTS, 0-2% slopes
GALT CLAY, 0-2% slopes
SAN JOAQUIN SILT LOAM, 0-3% slopes
SAN JOAQUIN-GALT COMPLEX, 0-3% slopes
TINNIN LOAMY SAND, 0-2% slopes
CLEAR LAKE CLAY, 0-2% slopes
CLEAR LAKE CLAY, HARDPAN SUBSTRATUM, 0-1% slopes
DIERSSEN SANDY CLAY LOAM, 0-2% slopes
DIERSSEN CLAY LOAM, 0-2% slopes
DURIXERALFS-GALT COMPLEX, 0-2% slopes
EGBERT CLAY, drained, 0-2% slopes
EGBERT CLAY, frequently flooded, 0-2% slopes
DWG. | DESCRIPTION | DATE
BASE | Digitize basemap (from Cartwright, 01/90) | 08/12/90
M-8 | SOIL TYPES | 06/29/90
CLIENT COUNTY OF SACRAMENTO
LOCATION NORTH STONE LAKE
DRAWN BY AJW ORIGINATOR RDS
SCALE 1":1400' DWG. MAP 8
NORTH
EA ENGINEERING, SCIENCE, AND TECHNOLOGY
41 LAFAYETTE CIRCLE - LAFAYETTE - CA - 94549 - (415) 283 7077

SOIL TYPES



VEGETATION AND LAND COVER TYPES



WILDLIFE HABITAT TYPES

TABLE 3-1 FREQUENT STORMS HYDRAULIC ANALYSIS

Condition	Peak Inflow (cfs)	Pump Capacity (cfs)	Peak Outflow (cfs)	Peak WSE (ft)
0.5-Year Event				
Existing	2,310	--	350	4.7
Future				
Alternative 1	5,990	1,500	365	4.7
Alternative 2	5,990	1,000	360	4.7
Alternative 3	5,990	330	450	5.8
2-Year Event				
Existing	3,950	--	430	5.9
Future				
Alternative 1	10,200	1,500	500	6.3
Alternative 2	10,200	1,000	500	6.3
Alternative 3	10,200	330	620	7.5
5-Year Event				
Existing	6,100	--	570	7.4
Future				
Alternative 1	14,300	1,500	660	8.0
Alternative 2	14,300	1,000	660	8.0
Alternative 3	14,300	330	750	8.8

TABLE 3-2 NORTH STONE LAKE WATER SURFACE ELEVATIONS

		Future Land Use[a]	
	Existing Conditions	Without Project	With Project[b]
Standard Project Flood	15.2	15.4	13.8
100-Year Flood	14.0	14.1	11.2
50-Year Flood	13.2	13.3	10.8
25-Year Flood	12.1	12.3	10.2
10-Year Flood	9.2	9.5	9.3

a. Projected, 204S.
b. With-project condition includes channel improvements up to the 800 cfs limit and a new bridge structure and road embankment at Lambert Road.

TABLE 3-3 ANALYSIS OF THREE-DAY STORM EVENTS[a]

	Existing Land Use		Future Land Use	
	Without Project	With Project	Without Project	With Project
100-yr 3-day storm	14.5	12.6	14.6	12.8
10-yr 3-day storm	11.3	11.2	11.8	11.8

a. Source: Gill and Pulver, 1988.

TABLE 4-1 WATER QUALITY CRITERIA FOR INORGANIC CHEMICALS

Inorganic Chemical	Protection of Human Health	Protection of Freshwater Aquatic Life
	(Micrograms/Liter)	
Arsenic	0.0022	190
Cadmium	10	0.55
Chromium	170,000	98
Copper	170,000	5.4
Lead	50	0.99
Mercury	0.144	0.012
Selenium	10	5
Zinc	5,000	49

Sources: Marshack. J.B. September 1988. A Compilation of Water Quality Goals. California Regional Water Quality Control Board, Central Valley Region.

EPA. 1986. Quality Criteria for Water 1986. EPA 440/5-86-001.

TABLE 4-2 WATER QUALITY MEASURED FOR THE NORTH AND SOUTH ARMS OF NORTH STONE LAKE

	North Arm		South Arm	
	12 Sep 89	04 May 90	12 Sep 89	04 May 90
Biochemical Oxygen Demand, mg/L	8	8	10	11
Non-filterable Residue (TSS), mg/L	26	60	30	34
Orthophosphorous, mg/L	0.1	0.14	0.1	0.15
Salinity, ppt	<1	<1	<1	<1
Nitrate (as NO3), mg/L	<0.4	<0.4	<0.4	<0.4
Arsenic, mg/L	0.006	0.005	0.006	0.004
Cadmium, mg/L	<0.01	<0.04	<0.01	<0.04
Copper, mg/L	<0.02	<0.08	<0.02	<0.08
Lead, mg/L	0.001	<0.3	<0.001	<0.3
Mercury, mg/L	<0.0001	<0.0001	<0.0001	<0.0001
Selenium, mg/L	<0.002	<0.002	<0.002	<0.002
Zinc, mg/L	0.03	<0.05	0.02	<0.05
Conductivity, umhos/cm		350		320
Fecal Coliform, MPN/100ml		4		4

TABLE 5-1 ACREAGE AND PROPORTIONATE EXTENT OF SOIL TYPES IN THE NORTH STONE LAKE AREA, SACRAMENTO COUNTY, CALIFORNIA

Soil Type	Acreage	Percentage of Study Area
Fluvaquents	74.8	2.9
Egbert clay, drained	218.5	8.5
Egbert clay, frequently flooded	19.5	0.8
Clear Lake clay	250.9	9.7
Clear Lake clay, hardpan substratum	122.7	4.7
Dierssen sandy clay loam	1,060.3	41.0
Dierssen clay loam	25.6	1.0
Tinnin loamy sand	98.8	3.8
San Joaquin silt loam	415.7	16.1
Galt clay	70.8	2.7
San Joaquin-Galt complex	91.6	3.5
Durixeralfs-Galt complex	21.1	0.8
Open Water	115.2	4.5
TOTALS	2,585.5	100.0

TABLE 5-2 SOIL LIMITATIONS FOR BUILDING SITE DEVELOPMENT AND SANITARY FACILITIES IN THE NORTH STONE LAKE AREA, SACRAMENTO COUNTY, CALIFORNIA[a]

Soil Type	Above-Ground Structures	All-Weather Roads	Paths and Trails	Shallow Excavations	Septic Tank Absorption Fields
Fluvaquents	Severe (flooding)	Severe (flooding)	Severe (flooding)	Severe (flooding)	Severe (flooding)
Egbert clay, drained	Severe (low strength, flooding, skrink-swell)	Severe (low strength, flooding, shrink-swell)	Severe (too clayey)	Moderate (too clayey, wetness, flooding)	Severe (flooding, wetness, percs slowly)
Egbert clay, frequently flooded	Severe (flooding, shrink-swell)	Severe (low strength, flooding, shrink-swell)	Severe (too clayey)	Moderate (too clayey, wetness, flooding)	Severe (flooding, wetness, percs slowly)
Clear Lake clay	Severe (flooding, shrink-swell)	Severe (low strength, flooding, shrink-swell)	Moderate (too clayey, flooding)	Severe (cut banks cave)	Severe (flooding, wetness, percs slowly)
Clear Lake clay, hardpan substratum	Severe (flooding, shrink-swell)	Severe (shrink-swell, low strength)	Moderate (too clayey)	Severe (cut banks cave)	Severe (percs slowly)
Dierssen sandy clay loam	Severe (flooding, shrink-swell)	Severe (shrink-swell, low strength, wetness)	Severe (wetness)	Severe (cemented pan, wetness)	Severe (flooding, cemented pan, wetness)
Dierssen clay loam	Severe (flooding, wetness, shrink-swell)	Severe (shrink-swell, low strength, wetness)	Severe (wetness)	Severe (cemented pan, wetness)	Severe (flooding, cemented pan, wetness)
Tinnin loamy sand	Slight	Slight	Moderate (too sandy)	Severe (cutbanks cave)	Severe (poor filter)
San Joaquin silt loam	Severe (flooding, shrink-swell)	Severe (shrink-swell, low strength)	Severe (erodes easily)	Severe (cemented pan)	Severe (cemented pan, percs slowly)

a. Source: Soil survey of Sacramento County, California (Tugel 1985).

TABLE 5-2 (Continued)

Soil Type	Above-Ground Structures	All-Weathered Roads	Paths and Trails	Shallow Excavations	Septic Tank Absorption Fields
Galt clay	Severe (flooding, shrink-swell)	Severe (low strength, shrink-swell)	Moderate (too clayey)	Severe (cemented pan, cutbanks cave)	Severe (cemented pan, percs slowly)
San Joaquin-Galt complex	See above[b]	See above	See above	See above	See above
Durixeralfs-Galt complex	No data[c]	No data	No data	No data	No data
Open Water	N/A	N/A	N/A	N/A	N/A

b. Areas mapped as San Joaquin-Galt complex consist of San Joaquin silt loam on low mounds and Galt clay in the intervening small depressions.

c. Areas mapped as Durixeralfs-Galt complex occur in a narrow strip along the west side of Interstate 5. They are altered soils for which no data on limitations have been described.

TABLE 5-3 SOIL LIMITATIONS FOR WATER MANAGEMENT IN THE NORTH STONE LAKE AREA, SACRAMENTO COUNTY, CALIFORNIA[a]

Soil Type	Ponds and Reservoirs	Embankments, Dikes and Levees	Drainage	Irrigation	Terraces and Diversions
Fluvaquents	Slight	Severe (flooding)	Frequently flooded	Frequently flooded	Frequently flooded
Egbert clay, drained	Slight	Moderate (hard to pack, wetness)	High water table	Slow intake, percs slowly, flooding	Percs slowly
Egbert clay, frequently flooded	Slight	Moderate (hard to pack, wetness)	High water table	Slow intake, percs slowly, flooding	Percs slowly
Clear Lake clay	Slight	Moderate (hard to pack, wetness)	High water table	Slow intake, percs slowly, flooding	Percs slowly
Clear Lake clay, hardpan substratum	Moderate (cemented pan)	Moderate (thin layer, hard to pack)	High water table	Slow intake, percs slowly	Percs slowly
Dierssen sandy clay loam	Moderate (cemented pan)	Severe (thin layer, wetness)	Percs slowly, cemented pan, flooding	Wetness, percs slowly, cemented pan	Cemented pan, wetness, percs slowly

a. Source: Soil Survey of Sacramento County, California (Tugel 1985).

TABLE 5-3 (Continued)

Soil Type	Ponds and Reservoirs	Embankments, Dikes and Levees	Drainage	Irrigation	Terraces and Diversions
Dierssen clay loam	Moderate (cemented pan)	Severe (thin layer, wetness)	Percs slowly, cemented pan, flooding	Wetness, percs slowly, cemented pan	Cemented pan, wetness, percs slowly
Tinnin loamy sand	Severe (seepage)	Severe (seepage, piping)	Well drained	Droughty, fast intake	Too sandy, soil blowing
San Joaquin silt loam	Moderate cemented pan)	Severe (thin layer)	Perched water table	Percs slowly	Cemented pan, erodes easily
Galt clay	Moderate cemented pan)	Moderate (thin layer, hard to pack)	Perched water table	Slow intake, percs slowly, cemented pan	Cemented pan, percs slowly
San Joaquin-Galt complex	See above[b]	See above	See above	See above	See above
Durixeralfs-Galt complex	No data[c]	No data	No data	No data	No data
Open Water	N/A	N/A	N/A	N/A	N/A

b. Areas mapped as San Joaquin-Galt complex consist of San Joaquin silt loam on low mounds and Galt clay in the intervening small depressions.

c. Areas mapped as Durixeralfs-Galt complex occur in a narrow strip along the west side of Interstate 5. They are altered soils for which no data on limitations have been described.

TABLE 6-1 FIVE LARGEST FAMILIES OF VASCULAR FLORA, NORTH STONE LAKE AREA, SACRAMENTO COUNTY, CALIFORNIA

Family	Genera	Native Plus Naturalized Taxa	Pct. of All Taxa
Poaceae (Grass Family)	22	9 + 29	17
Asteraceae (Sunflower Family)	26	21 + 14	16
Fabaceae (Pea Family)	8	10 + 12	10
Brassicaceae (Mustard Family)	7	3 + 8	5
Polygonaceae (Buckwheat Family)	2	5 + 5	4

TABLE 6-2 TEN LARGEST GENERA OF VASCULAR FLORA, NORTH STONE LAKE AREA, SACRAMENTO COUNTY, CALIFORNIA

Genus	Native Plus Naturalized Taxa
Trifolium (clovers)	6 + 4
Polygonum (knotweeds, smartweeds)	4 + 2
Salix (willows)	5 + 0
Hordeum (ryes)	2 + 3
Plagiobothrys (popcorn-flowers)	4 + 0
Lepidium (peppergrasses)	2 + 2
Spergularia (sand-spurrys)	1 + 3
Rumex (docks)	1 + 3
Avena (oats)	0 + 4
Erodium (filarees)	0 + 4

TABLE 6-3 CROSS-INDEX OF CALIFORNIA NATURAL DIVERSITY DATA BASE (CNDDB) NATURAL COMMUNITY TYPES, WILDLIFE HABITAT RELATIONSHIPS (WHR) SYSTEM HABITAT TYPES, PLANT COMMUNITY TYPES OF MUNZ (1973), AND U.S. FISH AND WILDLIFE SERVICE WETLAND TYPES IN THE NORTH STONE LAKE AREA, SACRAMENTO COUNTY, CALIFORNIA

Vegetation and Land Cover Types in the North Stone Lake Area (Map 6)	CNDDB Natural Community Types	WHR Habitat Types	Plant Communities of Munz (1973)	FWS Wetland Types
Non-native Grassland	Non-native Grassland (42200)	Annual Grassland	Valley Grassland	Palustrine/Emergent/ Temporarily Flooded (in part)
Northern Hardpan Vernal Pool	Northern Hardpan Vernal Pool (44110)	Annual Grassland	Valley Grassland	Palustrine/Emergent/ Temporarily Flooded (in part)
Valley Freshwater Marsh	Coastal and Valley Freshwater Marsh (52410)	Fresh Emergent Wetland	Freshwater Marsh	Palustrine/Emergent/ Permanently Flooded
				Palustrine/Emergent/ Seasonally Flooded
		Lacustrine (in part)		Lacustrine/Littoral/ Aquatic Bed/Rooted Vascular
Great Valley Riparian Forest	Great Valley Riparian Forest (61400)	Valley Foothill Riparian	Not applicable	Palustrine/Forested
Irrigated Pasture	Not applicable	Pasture	Not applicable	Not applicable
Introduced Trees	Not applicable	Not applicable	Not applicable	Not applicable
Open Water	Not applicable	Riverine	Not applicable	Riverine
		Lacustrine (in part)	Not applicable	Lacustrine/Limnetic

TABLE 6-3 CROSS-INDEX OF CALIFORNIA NATURAL DIVERSITY DATA BASE (CNDDB) NATURAL COMMUNITY TYPES, WILDLIFE HABITAT RELATIONSHIPS (WHR) SYSTEM HABITAT TYPES, PLANT COMMUNITY TYPES OF MUNZ (1973), AND U.S. FISH AND WILDLIFE SERVICE WETLAND TYPES IN THE NORTH STONE LAKE AREA, SACRAMENTO COUNTY, CALIFORNIA

Vegetation and Land Cover Types in the North Stone Lake Area (Map 6)	CNDDB Natural Community Types	WHR Habitat Types	Plant Communities of Munz (1973)	FWS Wetland Types
Non-native Grassland	Non-native Grassland (42200)	Annual Grassland	Valley Grassland	Palustrine/Emergent/ Temporarily Flooded (in part)
Northern Hardpan Vernal Pool	Northern Hardpan Vernal Pool (44110)	Annual Grassland	Valley Grassland	Palustrine/Emergent/ Temporarily Flooded (in part)
Valley Freshwater Marsh	Coastal and Valley Freshwater Marsh (52410)	Fresh Emergent Wetland	Freshwater Marsh	Palustrine/Emergent/ Permanently Flooded
				Palustrine/Emergent/ Seasonally Flooded
		Lacustrine (in part)		Lacustrine/Littoral/ Aquatic Bed/Rooted Vascular
Great Valley Riparian Forest	Great Valley Riparian Forest (61400)	Valley Foothill Riparian	Not applicable	Palustrine/Forested
Irrigated Pasture	Not applicable	Pasture	Not applicable	Not applicable
Introduced Trees	Not applicable	Not applicable	Not applicable	Not applicable
Open Water	Not applicable	Riverine	Not applicable	Riverine
		Lacustrine (in part)	Not applicable	Lacustrine/Limnetic

TABLE 6-4 ACREAGES OF VEGETATION AND LAND COVER TYPES IN THE NORTH STONE LAKE AREA

Vegetation/Cover Type	Acreage	Percent of Total Site Acreage
Open Water	147.7[a]	5.6
Non-native Grassland	2,150.4	81.1
Northern Hardpan Vernal Pool	0.5	<0.1
Valley Freshwater Marsh	125.7	4.7
Central Valley Riparian Forest	55.3	2.1
Irrigated Pasture	167.7	6.3
Introduced Trees	3.6	0.1
TOTAL	2,650.9	100.0

a. Open water acreage includes 82.3 acres for North Stone Lake proper and 65.4 acres for the borrow channel forming the western boundary of the site.

TABLE 6-5 BOTANICAL FIELD SURVEY DATES IN THE NORTH STONE LAKE AREA, SACRAMENTO COUNTY, CALIFORNIA

Survey Date	Area(s) of Emphasis
6 October 1989	Preliminary site reconnaissance; permanent and seasonal wetlands on margins of North Stone Lake; irrigated pasture areas
4 November 1989	Permanent and seasonal wetlands adjoining the borrow channel on the western site boundary
5 December 1989	Site reconnaissance
23 March 1990	Grasslands
31 March 1990	Grasslands; irrigated pasture areas
15 April 1990	Vernal pools and ephemeral wetlands
18 April 1990	Vernal pools and ephemeral wetlands
20 April 1990	Vernal pools and ephemeral wetlands
26 April 1990	Vernal pools and ephemeral wetlands
14 May 1990	Vernal pools and ephemeral wetlands
21 May 1990	Vernal pools and ephemeral wetlands
2 July 1990	Permanent and seasonal wetlands

TABLE 7-1 ACREAGES OF WETLAND TYPES IN THE NORTH STONE LAKE AREA

Wetland Type	Acreage	Percentage of Total Wetland Acreage	Percentage of Total Site Acreage
Lacustrine/Limnetic	82.1	16.0	3.1
Lacustrine/Littoral	33.1	6.4	1.2
Riverine	65.4	12.7	2.5
Palustrine/Forested	55.3	10.8	2.1
Palustrine/Emergent/Permanently Flooded	47.7	9.3	1.8
Palustrine/Emergent/Seasonally Flooded	44.9	8.7	1.7
Palustrine/Emergent/Temporarily Flooded	185.5	36.1	7.0
TOTALS	514.0	100.0	19.4

TABLE 8-1 WHR WILDLIFE HABITAT TYPES AND CODES FOR NORTH STONE LAKE

WHR HABITAT TYPE CODE	STAND TYPE
VRI 4D	Valley Foothill Riparian
VRI 6	
FEW 1D	Freshwater Emergent Wetland
FEW 2D	
AGS 2D	Annual Grassland
CRP	Cropland
LAC 3M	Lacustrine

STANDARDS FOR TREE SIZE

WHR No.	Trees	Hardwood crown diameter	Diameter at breast height
1	Seedling	n/a	<1"
2	Sapling	<15'	1"-6"
3	Pole	15'-30'	6"-11"
4	Small	30'-45'	11"-24"
5	Medium/ Large	>45'	>24"
6	Muti-layered	Size class 5 trees over a distinct layer of size class 4 or 3 trees, total tree canopy exceeds 60% closure.	

STANDARDS FOR CANOPY CLOSURE

WHR No.	Closure Class	Trees and Shrubs
S	Sparse	10-24%
P	Open	25-39%
M	Moderate	40-59%
D	Dense	60-100%

STANDARDS FOR HERB HEIGHT

WHR No.	WHR Height Class	Herb Height at maturity
1	Short Herb	<12"
2	Tall Herb	>12"

STANDARDS FOR CANOPY CLOSURE / GROUND COVER

WHR No.	Closure Class	Ground Cover
S	Sparse	2-9%
P	Open	10-39%
M	Moderate	40-59%
D	Dense	60-100%

STANDARDS FOR AQUATIC ZONES

Aquatic Zone	Zone Number	Standard
Pelagic (1,2) Limnetic (3) Open Water (4)	1	Open waters, not closely associated with shoreline or bottom.
Subtidal (1,2) Submerged (3,4)	2	Substrate continually submerged.
Intertidal (1,2) Periodically Flooded (3,4)	3	Substrate flooded periodically.
Shore (1,2,3,4)	4	Substrate continually exposed and not occupied by vegetation (<2% canopy closure).
1-Marine; 2-Estuarine; 3-Lacustrine; 4-Riverine		

STANDARDS FOR AQUATIC SUBSTRATES

Substrate	Substrate Letter	Standard
Organic	O	Composed primarily of organic material.
Mud	M	Wet, soft clays and silts covering at least 75% of the surface.
Sand	S	Coarse grained sediments covering at least 75% of the surface.
Gravel/Cobble	G	Rock fragments <3" covering at least 75% of the surface.
Rubble/Boulders	R	Rock fragments >3" covering at least 75% of the surface.
Bedrock	B	Bedrock covering at least 75% of the surface.

Classification system follows Laudenslayer, Jr. and Mayer (1988).

TABLE 8-2 SPECIAL STATUS SPECIES OBSERVED AT THE NORTH STONE LAKE AREA, 1989-1990

Common Name	Scientific Name	Status[a]
Aleutian Canada goose	*Branta canadensis*	FE
Tri-colored blackbird	*Agelaius tricolor*	2
Swainson's hawk	*Buteo swainsoni*	CT, 2
Giant garter snake	*Thamnophis couchi*	CT, 2
Western pond turtle	*Clemmys marmorata*	CSC, 2
American white pelican	*Pelecanus erythrorhynchos*	CSC
Double-crested cormorant	*Phalacrocorax auritus*	CSC
California gull	*Larus californicus*	CSC
Golden eagle	*Aquila chrysaetos*	CSC
Northern harrier	*Circus cyaneus*	CSC
Northern goshawk	*Accipiter gentilis*	CSC
Prairie falcon	*Falco mexicanus*	CSC
Yellow warbler	*Dendroica petechia*	CSC
American badger	*Taxidea taxus*	CSC
California tiger salamander	*Ambystoma tigrinum*	CSC

a. FE = Federally endangered species; 2 = Federal Category 2 candidate endangered species; CT = California threatened species; CSC = California species of concern.

TABLE 8-3 WILDLIFE SPECIES OBSERVED AT NORTH STONE LAKE

FISHES
(17 species)

Common Name	Scientific Name
Threadfin shad	*Dorosoma petenense*
Sacramento blackfish	*Orthodon microlepidotus*
Mississippi silverside	*Menidia audens*
Common bluegill	*Lepomis macrochirus*
White crappie	*Pomoxis annularis*
Black crappie	*Pomoxis nigromaculatus*
Carp	*Cyprinus carpio*
Bigscale logperch	*Percina macrolepida*
Goldfish	*Carassius auratus*
Hitch	*Lavinia exilicauda*
White catfish	*Ictalurus catus*
Black bullhead	*Ictalurus melas*
Brown bullhead	*Ictalurus nebulosus*
Largemouth bass	*Micropterus salmoides*
Warmouth	*Lepomis gulosus*
Prickly sculpin	*Cottus asper*
Mosquitofish	*Gambusia affinis*

AMPHIBIANS
(3 species)

Common Name	Scientific Name
Western toad	*Bufo boreas*
Pacific tree frog	*Hyla regilla*
Bullfrog	*Rana catesbeiana*

REPTILES
(8 species)

Common Name	Scientific Name
Western pond turtle	*Clemmys marmorata*
Western fence lizard	*Sceloporus occidentalis*
California alligator lizard	*Gerrhonotus multicarinatus*
Western yellow-bellied racer	*Coluber constrictor*
Pacific gopher snake	*Pituophis melanoleucus*
California kingsnake	*Lampropeltis getulus*
Valley garter snake	*Thamnophis sirtalis*
Giant garter snake	*Thamnophis couchi*

BIRDS
(101 species)

I. SPECIES OBSERVED (1989/1990; * = denotes nesting/nuptial behavior)

Common Name	Scientific Name
Pied-billed grebe*	*Podilymbus podiceps*
Clark's grebe	*Podiceps nigricollis*
Double-crested cormorant*	*Phalacrocorax auritus*
Greater white-fronted goose	*Anser albifrons*
Canada goose	*Branta canadensis*
Snow goose	*Chen hyperborea*
Ross' goose	*Chen rossii*
Tundra swan	*Cygnus columbianus*
Sandhill crane	*Grus canadensis*
Wood cuck*	*Aix sponsa*
Pintail	*Anas acuta*
American wigeon	*Anas americana*
Northern shoveler	*Anas clypeata*
Green-winged teal	*Anas crecca*
Cinnamon teal*	*Anas cyanoptera*
Mallard*	*Anas platyrhynchos*
Gadwall*	*Anas strepera*
Lesser scaup	*Aythya affinis*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Canvasback	*Aythya valisinaria*
Common mrganser	*Mergus merganser*
Ruddy duck*	*Oxyuris jamaicensis*
American coot*	*Fulica americana*
Common moorhen	*Gallinula chloropus*
Greater yellowlegs	*Tringa melanoleuca*
American white pelican	*Pelecanus erythrorhynchos*
California gull	*Larus californicus*
Caspian tern	*Sterna caspia*
Forster's tern*	*Sterna forsteri*
Great blue heron*	*Ardea herodias*
Green-backed heron	*Butorides striatus*
Black-crowned night heron*	*Nycticorax nycticorax*
American bittern	*Botaurus lentiginosus*
Great egret*	*Casmerodius albus*
Snowy egret*	*Egretta thula*
Sora	*Porzana carolina*
Virginia rail	*Rallus limicola*
Black-necked stilt	*Himantopus mexicanus*
Killdeer*	*Charadrius vociferus*
Common snipe	*Gallinago gallinago*
Long-billed dowitcher	*Limnodromus scolopaceus*
Long-billed curlew	*Numenius americanus*
California quail*	*Callipepla californica*
Golden eagle	*Aquila chrysaetos*

BIRDS
(101 species)

I. SPECIES OBSERVED (1989/1990; * = denotes nesting/nuptial behavior)

Common Name	Scientific Name
Black-shouldered kite	*Elanus caeruleus*
Northern harrier	*Circus cyaneus*
Northern goshawk	*Accipiter gentilis*
Red-tailed hawk *	*Buteo jamaicensis*
Rough-legged hawk	*Buteo lagopus*
Swainson's hawk*	*Buteo swainsoni*
Prairie falcon	*Falco mexicanus*
American kestrel*	*Falco sparverius*
Turkey vulture	*Cathartes aura*
Great horned owl*	*Bubo virginianus*
Barn owl	*Tyto alba*
Short-eared owl	*Asio flammeus*
Belted kingfisher	*Ceryle alcyon*
Mourning dove	*Zenaida macroura*
Nuttall's woodpecker	*Picoides nuttallii*
Hairy woodpecker	*Picoides villosus*
Northern flicker	*Colaptes auratus*
Western kingbird	*Tyrannus verticalis*
Ash-throated flycatcher	*Myiarchus cinerascens*
Western flycatcher	*Empidonax difficilis*
Black phoebe	*Sayornis nigricans*
Horned lark	*Eremophila alpestris*
American (water) pipit	*Anthus spinoletta*
Cliff swallow*	*Hirundo pyrrhonota*
Barn swallow*	*Hirundo rustica*
Tree swallow*	*Tachycineta bicolor*
American crow	*Corvus brachyrhynchos*
Scrub jay	*Aphelocoma coerulescens*
Yellow-billed magpie*	*Pica nuttalli*
Plain titmouse	*Parus inornatus*
Bushtit	*Psaltriparus minimus*
Marsh wren*	*Cistothorus palustris*
House wren	*Troglodytes aedon*
Wrentit	*Chamaea fasciata*
Ruby-crowned kinglet	*Regulus calendula*
American robin	*Turdus migratorius*
European starling*	*Sturnus vulgaris*
Yellow-rumped warbler	*Dendroica coronata*
Yellow warbler	*Dendroica petechia*
Nashville warbler	*Vermivora ruficapilla*
Orange-crowned warbler	*Vermivora celata*
Red-winged blackbird*	*Agelaius phoeniceus*
Tricolored blackbird*	*Agelaius tricolor*
Brewer's blackbird	*Euphagus cyanocephalus*
Western meadowlark*	*Sturnella neglecta*

BIRDS
(101 species)

I. SPECIES OBSERVED (1989/1990; * = denotes nesting/nuptial behavior)

Common Name	Scientific Name
Brown-headed cowbird	*Molothrus ater*
Northern oriole*	*Icterus galbula*
Western tanager	*Piranga ludoviciana*
Song sparrow*	*Melospiza melodia*
Savannah sparrow*	*Passerculus sandwichensis*
Golden-crowned sparrow	*Zonotrichia atricapilla*
White-crowned sparrow	*Zonotrichia leucophrys*
Rufous-sided towhee	*Pipilo erythrophthalmus*
California (brown) towhee	*Pipilo fuscus*
House finch	*Carpodacus mexicanus*
American goldfinch	*Carduelis tristis*

MAMMALS
(23 species)

Common Name	Scientific Name
Big brown bat	*Eptesicus fuscus*
California myotis	*Myotis californicus*
Yuma myotis	*Myotis yumanensis*
Brazilian free-tailed bat	*Tadarida brasilensis*
Ornate shrew	*Sorex ornatus*
Western harvest mouse	*Reithrodontomys megalotis*
Deer mouse	*Peromyscus maniculatus*
House mouse	*Mus musculus*
California vole	*Microtus californicus*
Muskrat	*Ondatra zibethicus*
Norway rat	*Rattus norvegicus*
Long-tailed weasel	*Mustela frenata*
Black-tailed jack rabbit	*Lepus californicus*
Virginia opossum	*Didelphis virginiana*
River otter	*Lutra canadensis*
Beaver	*Castor canadensis*
Raccoon	*Procyon lotor*
Striped skunk	*Mephitis mephitis*
American badger	*Taxidea taxus*
Gray fox	*Urocyon cinereoargentus*
Red fox	*Vulpes fulva*
Coyote	*Canis latrans*
Columbian black-tailed deer	*Odocoileus columbianus*

TABLE 8-4 FISH COLLECTED BY CDFG DURING 1972 FISH RESCUE

Common Name	Number Collected	Average Weight (lb)
Black crappie	34,363	0.18
Largemouth bass	311	3.50
Bluegill	2,122	0.25
Warmouth ass	1,823	0.26
Brown bullhead	2,342	0.62
White catfish	28	2.43
Sacramento blackfish	5,037	2.30
Carp	4,457	2.32
Goldfish	1,100	2.00

TABLE 8-5 NUMBERS, SIZES, AND WEIGHTS OF FISH CAPTURED AT NORTH STONE LAKE, NOVEMBER 1989

Common Name	Number	Fork Length (mm) Avg	Fork Length (mm) Range	Weight (g) Avg	Weight (g) Range
Threadfin shad	109	51	29-94	2.1	0.2-11.5
Scaramento blackfish	21	142.5	74-424	13	4.5-22
Mississippi silverside	12	63.2	35-87	1.6	0.2-3.2
Common bluegill	9	81.0	29-110	13.9	0.2-26
Black crappie	9	147.3	63-255	71.2	3.2-274
Carp	5	395.8	135-564	51	51-51
Bigscale logperch	4	80.8	75-87	4.2	3.6-4.8
Goldfish	4	282.5	205-362	160	92-229
Hitch	2	82.5	60-105	8.1	2.2-14
Black bullhead	2	245.0	205-285	220	106-335
Largemouth bass	2	144.5	140-149	47	43-51
White crappie	1	75.0	75-75	5.7	--
Brown bullhead	1	200.0	200-200	113	--

TABLE 8-6 NUMBERS, SIZES, AND WEIGHTS OF FISH CAPTURED AT NORTH STONE LAKE, JUNE 1990

Common Name	Number	Fork Length (mm)		Weight (g)	
		Avg	Range	Avg	Range
Sacramento blackfish	25	250	119-439	441	22-1,300
Black crappie	10	264	192-312	335	130-540
Largemouth bass	9	330	195-421	849	116-1,700
Common bluegill	9	91	52-129	20	3-46
Mississippi silverside	3	71	62-76	3	2-4
White catfish	3	358	258-444	1,074	321-1,800
Warmouth	2	132	126-137	61	52-70
Prickly sculpin	2	92	85-98	10	8-12
Mosquitofish	2	37	32-42	1	1
Carp	1	508	508-508	2,750	--
Bigscale logperch	1	59	59-59	2	--
Goldfish	1	496	496-496	496	--
Black bullhead	1	337	337-337	270	--
White crappie	1	334	334-334	680	--

TABLE 8-7 WATERFOWL CENSUS (SPRING 1990)

Species	Number of Pairs	Number of Single Males[a]
Gadwall	1	1
Mallard	15	17
Cinnamon teal	7	7
Wood duck	2	
Ruddy duck[1]		
Pied-billed grebe[2]		

a. Females presumed on nest

1. One female.
2. (Sexes not distinguishable) 30 single birds; 6 females on nest.

TABLE 8-8 APRIL 1990 RIPARIAN NEST SURVEY

Species	Number of Active Nests
Great egret	52
Great blue heron	49
Black-crowned night heron	61
Snowy egret	20
Double-crested cormorant	17

TABLE 8-9 RESULTS OF APRIL 1990 SMALL MAMMAL TRAPPING

Species	# of Captures
California meadow vole	29
Western harvest mouse	24
Deer mouse	23

TABLE 10-1 PROJECTED RESIDENTIAL GROWTH IN THE DELTA AND SOUTH SACRAMENTO AREAS, 1988-2005

Community Area	Year			Change, 1988-2005	
	1988	1990	2005	Number	Percent
Delta					
Population	5,614	5,796	6,345	731	13
Housing Units	2,274	2,384	2,684	410	18
South Sacramento					
Population	102,200	114,822	155,069	52,869	52
Housing Units	38,807	44,609	64,141	25,334	65

Source: SACOG (Sacramento Area Council of Governments) "Growth Projections by Community Area," 10 February 1989.

TABLE 10-2 MAJOR COUNTY ROADS

Road	Segment	Daily Volume (For 24 Hours in Both Directions)	Current Capacity	Post-2000 Capacity*	Post-2000 Designation*
Hood Franklin-West	Hood to Interstate 5	2,060 (1984)	20,000	30,000	Arterial
Hood Franklin-East	Interstate 5 to Franklin		20,000	45,000	Thoroughfare (Connector Between I-5 and Hwy 99)
Franklin Boulevard	Franklin Area to Elk Grove Boulevard	2,548 (1988)	15,000	30,000	Arterial
	Elk Grove Boulevard to Meadowview Road		15,000	45,000	Thoroughfare
Elliot Ranch Road	Entire Length of Road	Not on File	Not on File	15,000	Local Street

* Potential road capacity under an urban development scenario for after the year 2000, from the Sacramento County Major Street and Highway Plan, 10 May 1990.

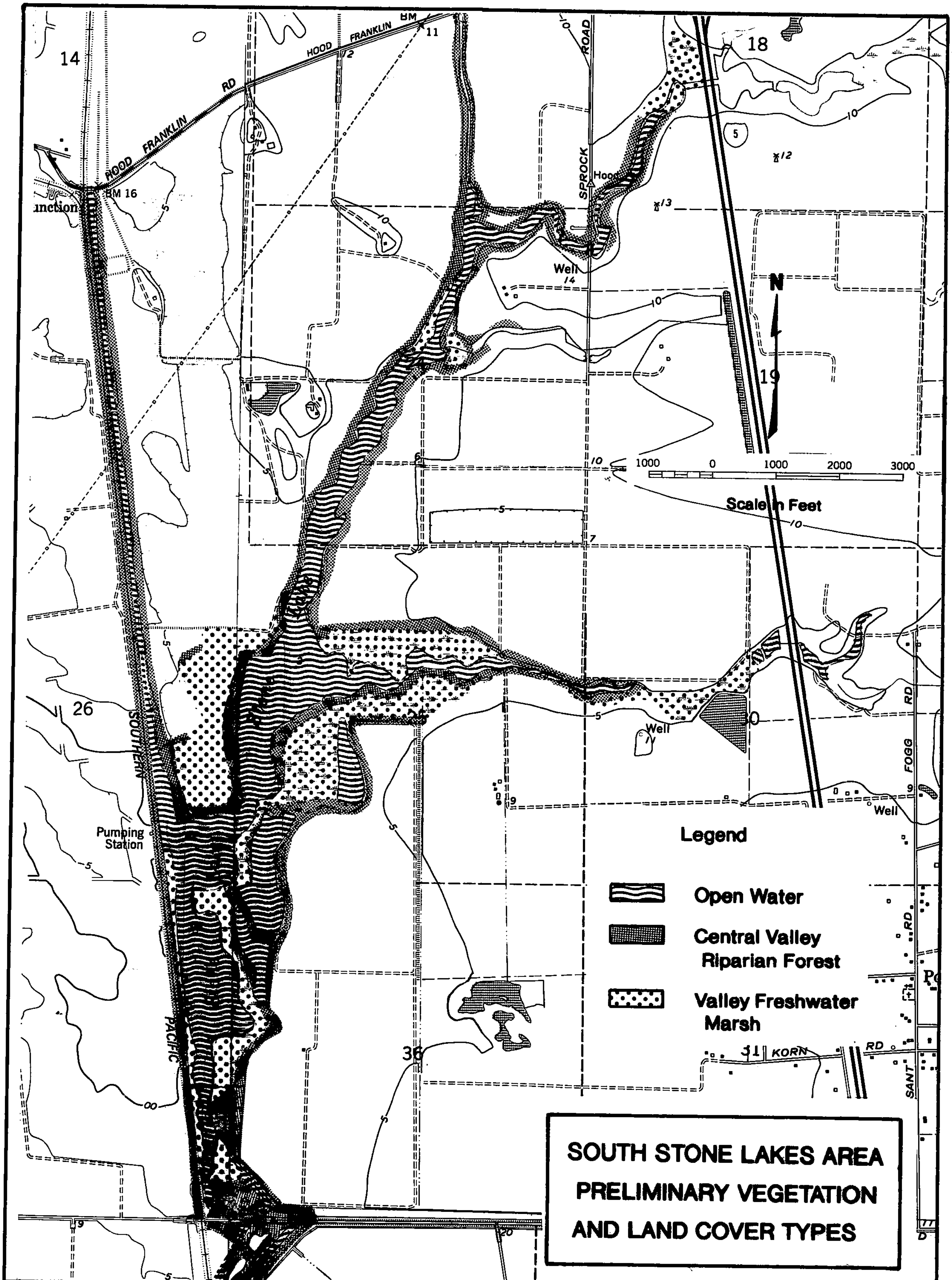
Source: Sacramento County Department of Public Works, 8 June 1990.

TABLE 10-3 STATE ROADS

Road	Segment	Annual Average Daily Traffic Volumes (Both Directions) 1989	Daily Average For Peak Month (August)	Capacity Adequacy Ratio[a]
I-5	Meadowview Road to Hood Franklin Road	35,000	43,000	79
Highway 160	Freeport to Hood	1,500	1,900	349

a. 100 = Minimum desirable value; 200 = Level of service could double before service begins to be undesirable.

Source: CALTRANS, Traffic Counts Department, 8 June 1990.


SOUTH STONE LAKES AREA
PRELIMINARY VEGETATION
AND LAND COVER TYPES
Legend
Open Water
Central Valley
Riparian Forest
Valley Freshwater
Marsh
Scale in Feet
1000
0
1000
2000
3000
N
HOOD FRANKLIN RD
SPROCK ROAD
FOGG RD
KORN RD
SOUTHERN
PACIFIC
Pumping
Station
Well
BM 16
14
18
19
26
36
31

Cosumnes River Preserve

SIZE: 1,454 acres

LOCATION: The preserve is located in Sacramento County on the eastern edge of the Sacramento-San Joaquin delta between California Highway 99 and Interstate 5. The nearest town is Walnut Grove.

HISTORY: The Miwok Indians once roamed the area, hunting, fishing for salmon and collecting acorns for a living. John Sutter first used the present spelling for the river in 1841. In later years settlers cleared much of the land for farming and cattle grazing, presently the prominent uses of the land surrounding the preserve.

GEOGRAPHY: Although nearly 100 miles from the ocean, the lower reaches of the Cosumnes River are affected by ocean tides funneling into the delta through San Francisco Bay, pushing fresh water back up the Cosumnes. The average elevation is less than ten feet, with low levees lining the river. The climate is Mediterranean, with hot, dry summers and cool, moist winters. Tule fogs are common in mid-winter. There are no major dams on the Cosumnes, allowing frequent flooding in response to heavy winter rains. The load of rich silt carried by floodwater introduces valuable nutrients to adjacent wetlands and grasslands. The Cosumnes is the largest free-flowing river in the Central Valley, and has been selected as a National Natural Landmark.

FLORA: The Cosumnes River Preserve protects two plant communities now rare: riparian (streamside) forest and freshwater marsh; less than 1% of each community remains intact in the state. The preserve supports the finest remaining example of valley oak riparian forest. Valley oak (Quercus lobata), and Fremont cottonwood (Populus fremontii), form the tall, continuous canopy. The grand height of this riparian forest is due to the abundance of

Cottonwood and willows
Illustration by Craig Latker

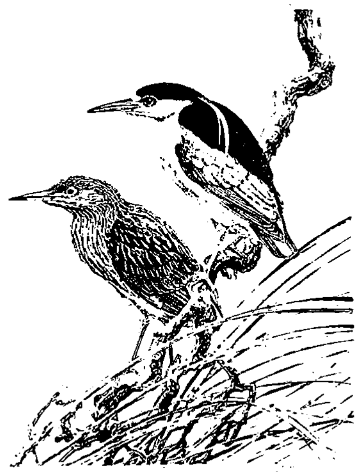
available water during the optimum growing temperatures of summer. Oregon ash (Fraxinus latifolia), box elder (Acer negundo californica), buttonwillow (Cephalanthus occidentalis) and four species of willows (Salix) thrive beneath the shady canopy. Great vines of wild grape (Vitus californica) festoon the trees, giving the forest an appearance that John Muir described as "tropical luxuriance."

Freshwater marshes bordering the forest support vigorous growth of swamp knotweed (Polygonum hydropiperoides), marsh primrose (Ludwigia peploides), tules (Scirpus), and cattails (Typha). Annual grasslands and cultivated fields occur in drier parts of the preserve.

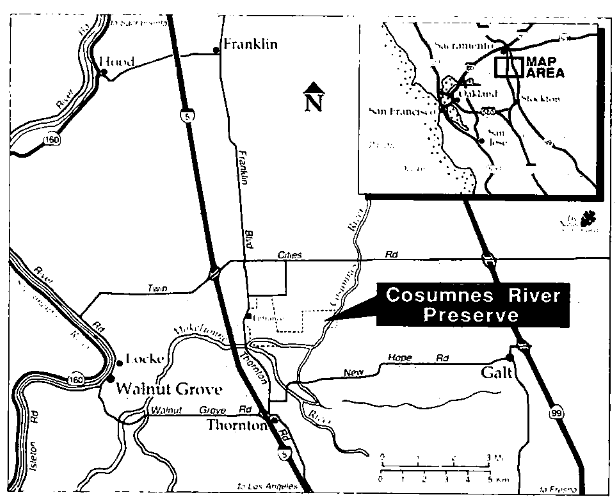
FAUNA: The river itself harbors runs of salmon and steelhead. River otter and muskrat also occupy the water. The bordering riparian forest is home to racoon, black-tailed mule deer, mink, ringtail and opossum. The Pacific tree frog is common. More than 200 species of birds have been recorded on and around the preserve, including several nesting pairs of Swainson's hawks. In winter, the marshes support impressive numbers of greater and lesser sandhill cranes, Ross's, white-fronted, and Canada geese, tundra swans and numerous species of ducks. Resident birds such as great blue herons, blackcrowned night herons and turkey vultures are common.

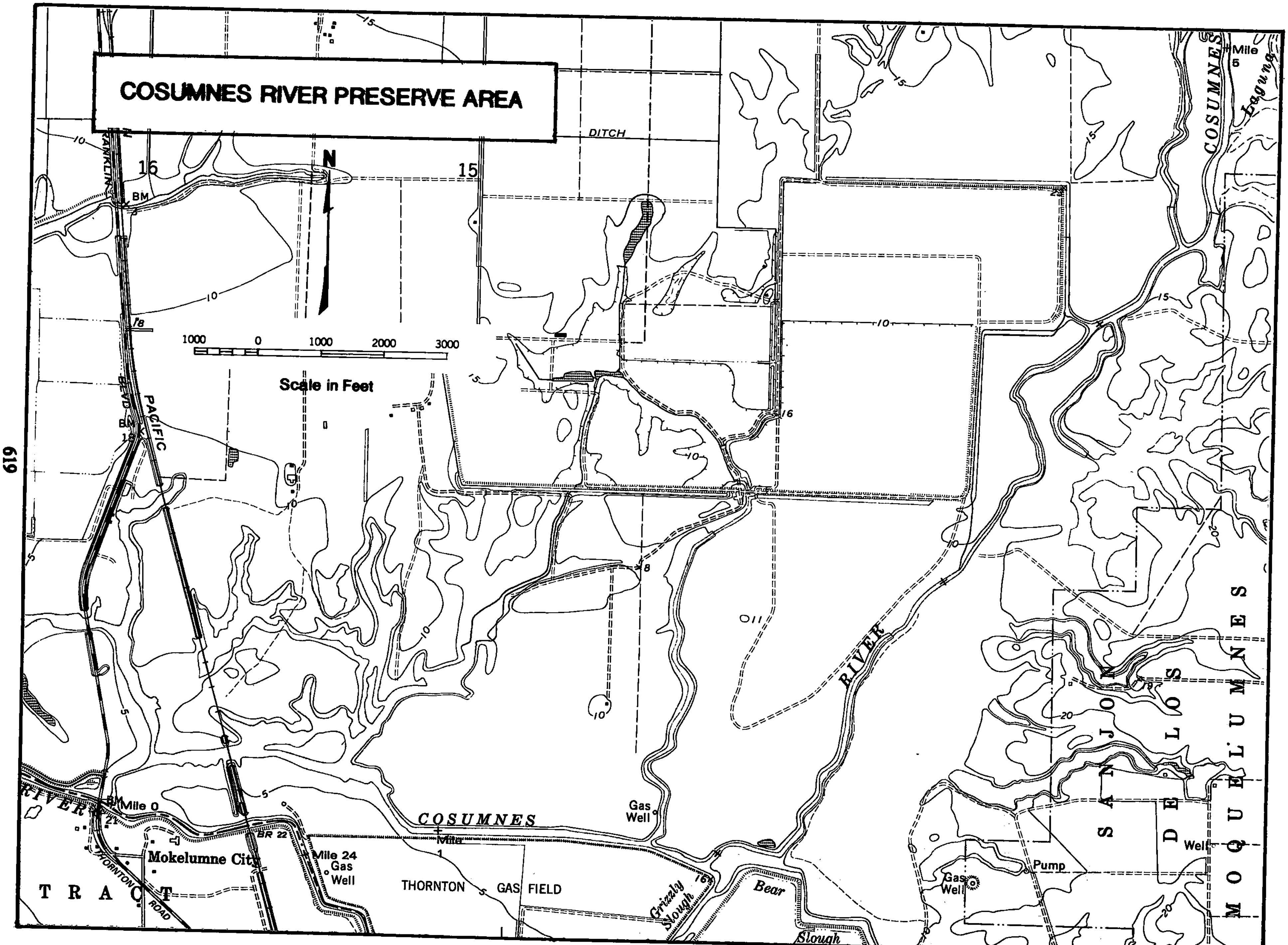
MANAGEMENT: The Cosumnes River Preserve is owned and managed by The Nature Conservancy. TNC, in partnership with Ducks Unlimited, Inc., has launched an ambitious restoration project in the Preserve, one of the first of its kind between the two conservation organizations. The Conservancy is restoring the riparian forests and Ducks

Unlimited is restoring the wetlands. Valley oaks, the dominent species, Oregon ash, Fremont's cottonwood, box elder, alder and elderberry are being planted to mimic the mixture of trees and shrubs found in the Cosumnes' riparian forest. When Ducks Unlimited completes its restoration work, water in the wetlands will be managed to create diverse aquatic plant communities during the spring and summer. They will provide nesting and brood-rearing habitats for waterfowl and resting and feeding areas for migrating and wintering birds.



Blackcrowned night herons
Illustration by Keith Hansen




COSUMNES RIVER PRESERVE AREA
Scale in Feet
1000 0 1000 2000 3000
N
DITCH
COSUMNES
RIVER
SAN JON DE LOS MOQUELUMNES
Mokelumne City
TRACT
THORNTON GAS FIELD
Gas Well
Mile 24
Mile 0
Mile 1
Mile 5
Grizzly Slough
Bear Slough
Pump
Well
PACIFIC BLVD
FRANKLIN
THORNTON ROAD
BR 22
BM
Laguna